APPENDIX 1:
SURVEY ON CURRENT ESCORT PRACTICE

The following questionnaire was sent to representatives of shipping companies (Polar Tankers/ConocoPhillips and Alaska Tanker Company), tug companies (Foss Maritime and Crowley Marine Services), and pilots (Puget Sound Pilots), to gather detailed information and any unique perspectives on current escort practice in Puget Sound. The responses to the survey are distilled and presented in Section 3.

1. Who selects the tug(s) that will be used in an escort? Who calculates the HP requirements? Who selects the tug type (VSP, ASD, Conventional) if all of them meet the HP requirement?

2. What is the role of the shipping agent?

3. How are foreign flag tankers escorted? Is it any different than escort of TAPs tankers?

4. When, where and how does the pre-escort conference take place?

    a. What items are discussed at pre-escort conference?

    b. Is the pre-escort conference of value to the safety of the escort?

    c. Are the possible emergency response maneuvers discussed?

    d. Is fire fighting discussed?

5. Where are the tugs normally positioned during an escort?

    e. Is there much variability in tug positioning between shipping companies, tug companies, pilots

    f. How does the placement of the escort tugs vary with weather conditions?

6. How often and when are tugs tethered for escort?

    g. If tethered, when and how is the tether made up? How long does it take?

    h. If not tethered, what is the plan for rigging up in the event of an emergency? How long is it anticipated that it will take?

7. Is the running start common practice? How does it work?

8. How often is there a one tug escort? How often is there a three tug escort? Why?

9. What is the assumed role for the secondary tug in the event of an emergency?

i. Is it expected that the second tug will push on the tanker to control heading? Will it be forward or aft on the tanker?

j. Is it expected the secondary tug will put up line?

k. What precautions are expected to be taken with respect to side-shell strength?

10. What are the transit speeds during escort?

    l. between Port Angeles and Davidson Rock?

    m. in Rosario Straits?

    n. in Guemes Channel?

    o. between Cherry Point and March Point?

    p. in Puget Sound?

11. Is there tanker escort in Haro Straits? How often and why?

12. Is the speed measured over-ground (GPS) or through the water (Doppler)?

13. Do the tugs record transit speed?

14. Does the escort down Puget Sound present any particular difficulties because it is so long?

15. How is the escort different in foul weather compared to fair weather? What constitutes foul weather for an escort?

16. How and how often are escort tug emergency response maneuvers practiced?

17. Is tug escort used for tankers other than oil tankers? Are there any?

18. What are the escort procedures for partially laden tankers?

19. Are any oil barges escorted?

20. Do and how do tugs communicate with tanker masters and pilots regarding navigation issues? Do tugs provide an extra set of eyes and ears and minds for the transit?

21. Are the escort tugs prepared to provide emergency towing (after the ship starts drifting)? Is towing discussed at the pre-escort conference?

22. Are the escort tugs prepared to provide first-response oil spill containment and clean-up? Are they expected to? Is this discussed at the pre-escort conference?

23. How has escort evolved since the OPA 90 federal regulations first started?

24. Are there any special issues or procedures when escorting double-hull single screw tankers?

25. Are there any special issues or procedures when escorting double-hull twin-screw tankers?

APPENDIX 2:
MARPOL AMENDMENTS ON THE PHASING OUT OF SINGLE-HULL TANKERS

The 1992 amendments
Adoption: 6 March 1992
Entry into force: 6 July 1993

The amendments to Annex I of the convention which deals with pollution by oil brought in the "double hull" requirements for tankers, applicable to new ships (tankers ordered after 6 July 1993, whose keels were laid on or after 6 January 1994 or which are delivered on or after 6 July 1996) as well as existing ships built before that date, with a phase-in period.

New-build tankers are covered by Regulation 13F, while regulation 13G applies to existing crude oil tankers of 20,000 dwt and product carriers of 30,000 dwt and above. Regulation 13G came into effect on 6 July 1995.

Regulation 13F requires all new tankers of 5,000 dwt and above to be fitted with double hulls separated by a space of up to 2 metres (on tankers below 5,000 dwt the space must be at least 0.76m).

As an alternative, tankers may incorporate the "mid-deck" concept under which the pressure within the cargo tank does not exceed the external hydrostatic water pressure. Tankers built to this design have double sides but not a double bottom. Instead, another deck is installed inside the cargo tank with the venting arranged in such a way that there is an upward pressure on the bottom of the hull.

Other methods of design and construction may be accepted as alternatives "provided that such methods ensure at least the same level of protection against oil pollution in the event of a collision or stranding and are approved in principle by the Marine Environment Protection Committee based on guidelines developed by the Organization.

For oil tankers of 20,000 dwt and above new requirements were introduced concerning subdivision and stability.

The amendments also considerably reduced the amount of oil which can be discharged into the sea from ships (for example, following the cleaning of cargo tanks or from engine room bilges). Originally oil tankers were permitted to discharge oil or oily mixtures at the rate of 60 litres per nautical mile. The amendments reduced this to 30 litres. For non-tankers of 400 grt and above the permitted oil content of the effluent which may be discharged into the sea is cut from 100 parts per million to 15 parts per million.

Regulation 24(4), which deals with the limitation of size and arrangement of cargo tanks, was also modified.

Regulation 13G applies to existing crude oil tankers of 20,000 dwt and product carriers of 30,000 dwt and above.

Tankers that are 25 years old and which were not constructed according to the requirements of the 1978 Protocol to MARPOL 73/78 have to be fitted with double sides and double bottoms. The Protocol applies to tankers ordered after 1 June 1979, which were begun after 1 January 1980 or completed after 1 June 1982. Tankers built according to the standards of the Protocol are exempt until they reach the age of 30.

Existing tankers are subject to an enhanced programme of inspections during their periodical, intermediate and annual surveys. Tankers that are five years old or more must carry on board a completed file of survey reports together with a conditional evaluation report endorsed by the flag Administration.

Tankers built in the 1970s which are at or past their 25th must comply with Regulation 13F. If not, their owners must decide whether to convert them to the standards set out in regulation 13F, or to scrap them.

Another set of tankers built according to the standards of the 1978 protocol will soon be approaching their 30th birthday - and the same decisions must be taken.

The 2001 amendments
Adoption: 27 April 2001
Entry into force: 1 September 2002

The amendment to Annex I brings in a new global timetable for accelerating the phase-out of single-hull oil tankers. The timetable will see most single-hull oil tankers eliminated by 2015 or earlier. Double-hull tankers offer greater protection of the environment from pollution in certain types of accident. All new oil tankers built since 1996 are required to have double hulls.

The revised regulation identifies three categories of tankers, as follows:

"Category 1 oil tanker" means oil tankers of 20,000 tons deadweight and above carrying crude oil, fuel oil, heavy diesel oil or lubricating oil as cargo, and of 30,000 tons deadweight and above carrying other oils, which do not comply with the requirements for protectively located segregated ballast tanks (commonly known as Pre-MARPOL tankers).

"Category 2 oil tanker" means oil tankers of 20,000 tons deadweight and above carrying crude oil, fuel oil, heavy diesel oil or lubricating oil as cargo, and of 30,000 tons deadweight and above carrying other oils, which do comply with the protectively located segregated ballast tank requirements (MARPOL tankers), while

"Category 3 oil tanker" means an oil tanker of 5,000 tons deadweight and above but less than the tonnage specified for Category 1 and 2 tankers.

Although the new phase-out timetable sets 2015 as the principal cut-off date for all single-hull tankers, the flag state administration may allow for some newer single hull ships registered in its country that conform to certain technical specifications to continue trading until the 25th anniversary of their delivery.

However, under the provisions of paragraph 8(b), any Port State can deny entry of those single hull tankers which are allowed to operate until their 25th anniversary to ports or offshore terminals. They must communicate their intention to do this to IMO.

As an additional precautionary measure, a Condition Assessment Scheme (CAS) will have to be applied to all Category 1 vessels continuing to trade after 2005 and all Category 2 vessels after 2010.

Although the CAS does not specify structural standards in excess of the provisions of other IMO conventions, codes and recommendations, its requirements stipulate more stringent and transparent verification of the reported structural condition of the ship and that documentary and survey procedures have been properly carried out and completed.

The requirements of the CAS include enhanced and transparent verification of the reported structural condition and of the ship and verification that the documentary and survey procedures have been properly carried out and completed. The Scheme requires that compliance with the CAS is assessed during the Enhanced Survey Programme of Inspections concurrent with intermediate or renewal surveys currently required by resolution A.744(18), as amended.

The 2003 Amendments
Adoption: 4 December 2003
Entry into force: April 2005

Under a revised regulation 13G of Annex I of MARPOL, the final phasing-out date for Category 1 tankers (pre-MARPOL tankers) is brought forward to 2005, from 2007. The final phasing-out date for category 2 and 3 tankers (MARPOL tankers and smaller tankers) is brought forward to 2010, from 2015.

The full timetable for the phasing out of single-hull tankers is as follows:

Category of oil tanker	**Date or year**
Category 1	5 April 2005 for ships delivered on 5 April 1982 or earlier 2005 for ships delivered after 5 April 1982
Category 2 and Category 3	5 April 2005 for ships delivered on 5 April 1977 or earlier 2005 for ships delivered after 5 April 1977 but before 1 January 1978 2006 for ships delivered in 1978 and 1979 2007 for ships delivered in 1980 and 1981 2008 for ships delivered in 1982 2009 for ships delivered in 1983 2010 for ships delivered in 1984 or later

Under the revised regulation, the Condition Assessment Scheme (CAS) is to be made applicable to all single-hull tankers of 15 years, or older. Previously it was applicable to all Category 1 vessels continuing to trade after 2005 and all Category 2 vessels after 2010. Consequential enhancements to the CAS scheme were also adopted.

The revised regulation allows the Administration (flag State) to permit continued operation of category 2 or 3 tankers beyond 2010 subject to satisfactory results from the CAS, but the continued operation must not go beyond the anniversary of the date of delivery of the ship in 2015 or the date on which the ship reaches 25 years of age after the date of its delivery, whichever is earlier.

In the case of certain Category 2 or 3 oil tankers fitted with only double bottoms or double sides not used for the carriage of oil and extending to the entire cargo tank length or double hull spaces, not meeting the minimum distance protection requirements, which are not used for the carriage of oil and extend to the entire cargo tank length, the Administration may allow continued operation beyond 2010, provided that the ship was in service on 1 July 2001, the Administration is satisfied by verification of the official records that the ship complied with the conditions specified and that those conditions remain unchanged. Again, such continued operation must not go beyond the date on which the ship reaches 25 years of age after the date of its delivery

APPENDIX 3:
IMO GUIDELINE OIL OUTFLOW METHODOLOGY

Probabilistic analysis, whether it is for ship damage stability or oil outflow, is based on evaluating the cumulative probability of occurrence of an expected consequence (survival or quantity of outflow). It is typically formulated in terms of the following conditional probabilities:

- the probability that the ship will encounter damage;

- the probability of the damage location and extent;

- the probability of survival or expected consequences.

Evaluation of all of these probabilities would constitute a fully probabilistic evaluation for a specific vessel on a specific route.

The IMO Guidelines do not specifically deal with the probability of whether the ship will encounter damage. Instead, it is acknowledged that the risk does exist, and assumes that in fact, the vessel has been involved in a casualty event significant enough to breach at least one compartment. The methodology deals exclusively with determination of the probability of damage extent (once damage has occurred) and calculation of the resulting consequences.

The basic method is outlined below. A discussion of each aspect of the method follows the outline. The IMO Guidelines call for a "Conceptual" analysis to obtain approval for an alternative tanker concept, and a damaged stability or "Survivability" analysis for the final shipyard design. Differences in these approaches are explained in the text.

A) Establish the Intact Load Condition: Develop models for each design. Perform full load trim and stability calculations to determine initial intact draft and GM_t conditions.

B) Assemble Damage Cases: Assemble damage cases for each possible combination of compartments by applying the damage density distribution functions included in the *Guidelines*, for both side and bottom damage.

C) Compute the Oil Outflow for Each Damage Case: Both a "Conceptual" analysis and a "Survivability" analysis were performed for each model.

   "Conceptual" Analysis: Damage equilibrium calculations are not required for the "Conceptual" analysis. This approach assumes that the vessel subjected to side damage always survives, and the vessel subject to bottom damage always remains stranded on the shelf without trim or heel.

   "Survivability" Analysis: Calculate the survivability and equilibrium condition for each damage case. Side damage is assumed to result in a free floating vessel. Bottom damage is assumed to result in a grounded vessel unless loss of oil allows the vessel to float free.

   For bottom damage a hydrostatic balance method is used to compute outflow. For side damage, all oil is assumed to escape from damaged tanks. (Note: For the

"Survivability" analysis, all cargo on board is assumed to flow out for those cases which result in loss of the vessel.)

D) Compute the Oil Outflow Parameters: Develop the cumulative probability of occurrence of each level of oil outflow and the associated oil outflow parameters.

E) Compute the Pollution Prevention Index "E": The pollution prevention index "E" is computed using the formula provided in the IMO Guidelines. The design is equivalent to the reference hull, or in this case the "rule" double hull, if "E" is greater than or equal to 1.0.

A) Establish the Intact Condition

Hull offset, compartment offset and ship data files were developed for each design utilizing the HEC Salvage Engineering Software (HECSALV).

Consistent with the IMO Guidelines, oil outflow calculations were carried out assuming the vessel is initially at a mean draft equal to its scantling load line, with zero trim and zero heel. To establish the density of the cargo oil, load cases were developed based upon the tankers full load departure condition, assuming all cargo tanks 98% full and departure consumables. Calculations assume the vessel is floating in seawater with a specific gravity of 1.025.

B) Assemble Damage Cases

The probability of the damage location and extent has been statistically estimated from surveys of past damage. This compilation of damage statistics continues today and is being coordinated by the IMO. The general framework of current and pending probabilistic regulations allow them to be updated with improved damage statistics as the data becomes available. As part of this effort damage statistics for tankers have been collected for IMO by the classification societies [10,11]. These statistics are based upon 52 collisions and 63 groundings involving tankers above 30,000 metric tons deadweight capacity, but are also used for regulatory assessment of smaller vessels. This data is used as the basis for the damage probabilities in the proposed IMO Guidelines under Regulation 13F. The side damage and bottom damage distributions as specified in the IMO Guidelines and as applied in this report are presented as Figures 1 through 10.

Damage statistics are generally presented as graphs of probability density distributions. The area under the probability density histogram or curve between two points on the horizontal axis is the probability that the quantity will fall within that range. The density distribution scales are normalized by ship length for location and longitudinal extent, by ship breadth for transverse extent and transverse extent, and by ship depth for vertical location and vertical extent. Statistics for location, extent, and penetration are developed separately for side and bottom damage cases.

For side damage, the probability of a given longitudinal location, longitudinal extent, transverse penetration, vertical location and vertical extent is the product of the probability of the location, by the probability of the length, by the probability of the transverse extent of damage, by the probability of the vertical location, by the probability of the vertical extent of damage. Similarly, bottom damage includes evaluation of the longitudinal location of damage, longitudinal extent, vertical penetration, transverse location and transverse extent.

The histogram data and the probability density functions developed from them represent "marginal" distributions. That is, location, extent and penetration are presented independently. It is expected that there will be some correlation; however, correlated statistics are unavailable. This is a conservative assumption, as correlated statistics will tend to reduce the likelihood of concurrent application of extreme extents, and therefore reduce the projected oil outflow.

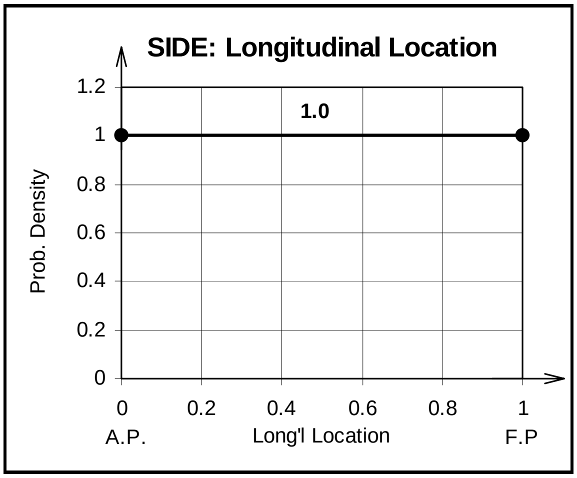


Figure 1

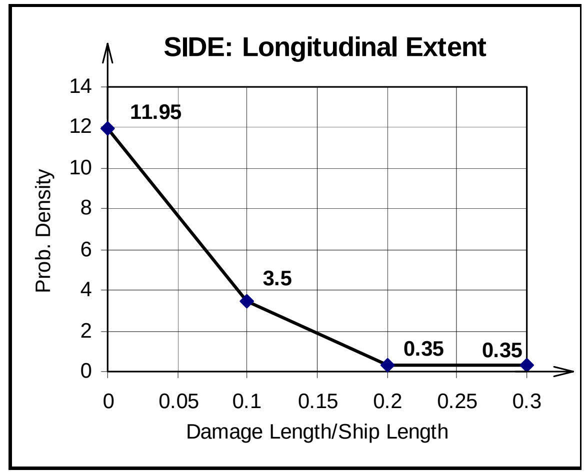


Figure 2

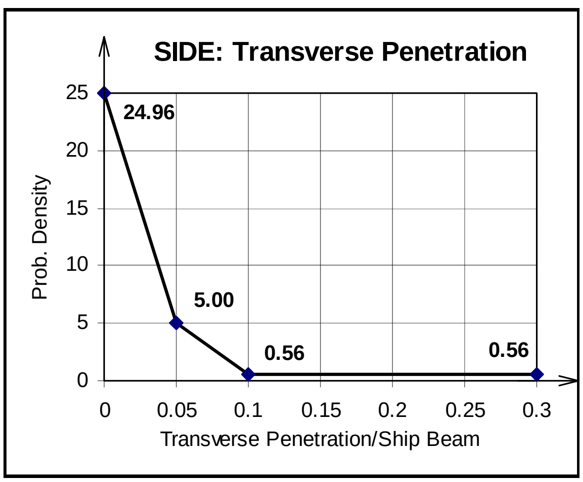


Figure 3

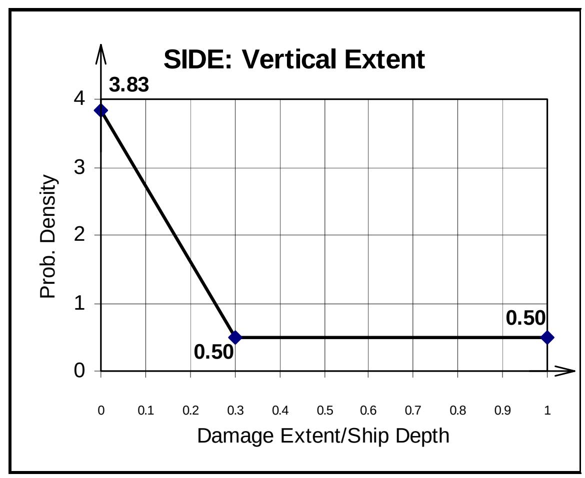


Figure 4

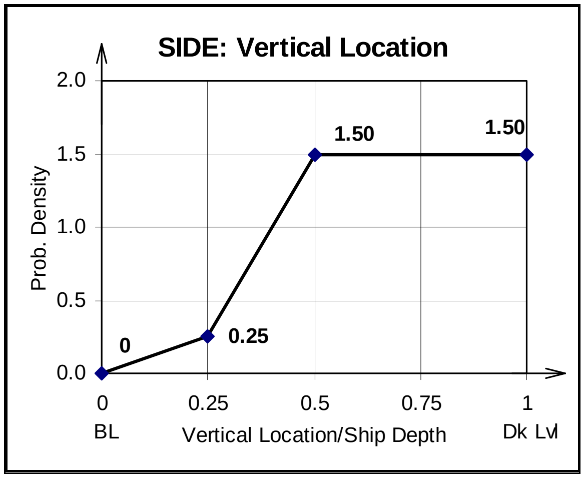


Figure 5

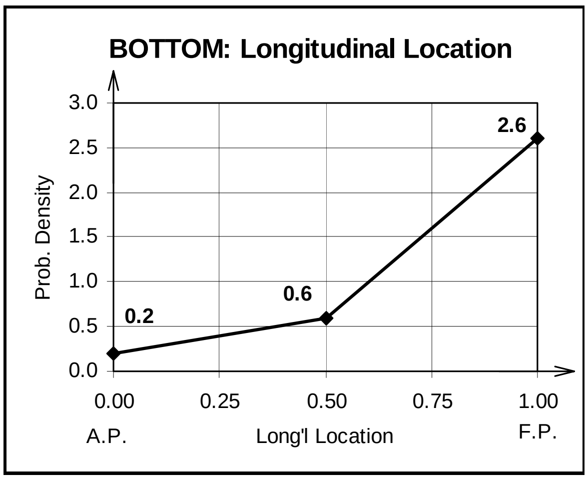


Figure 6

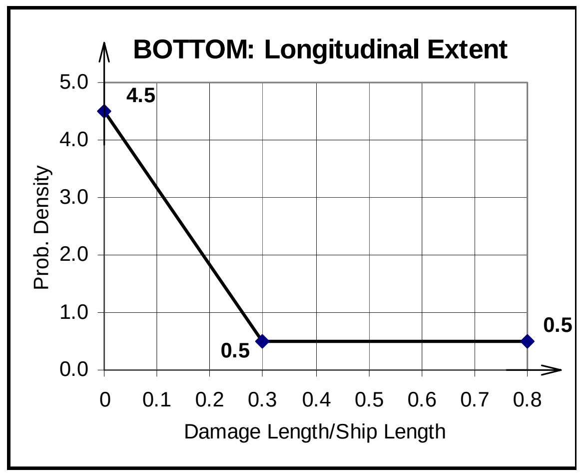


Figure 7

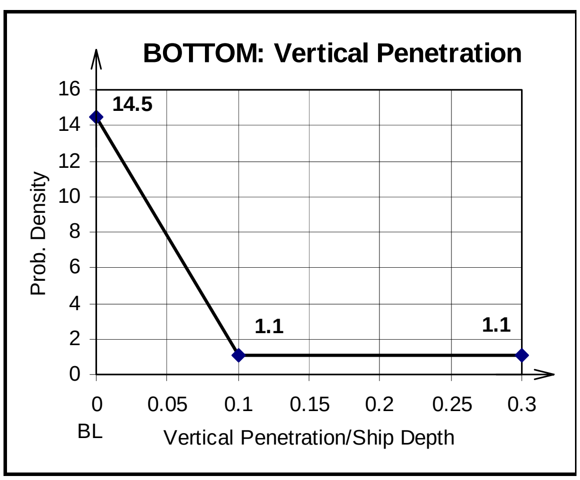


Figure 8

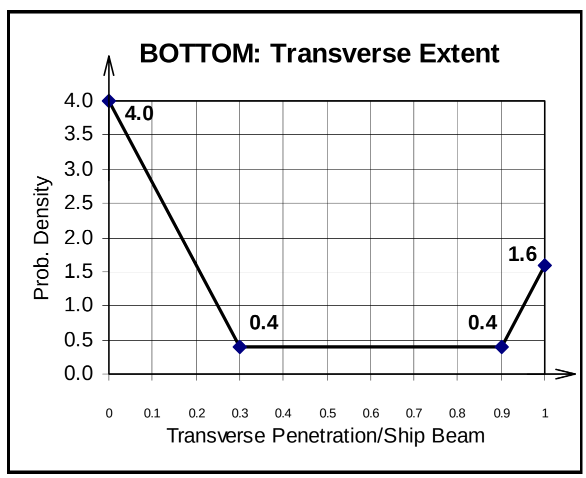


Figure 9

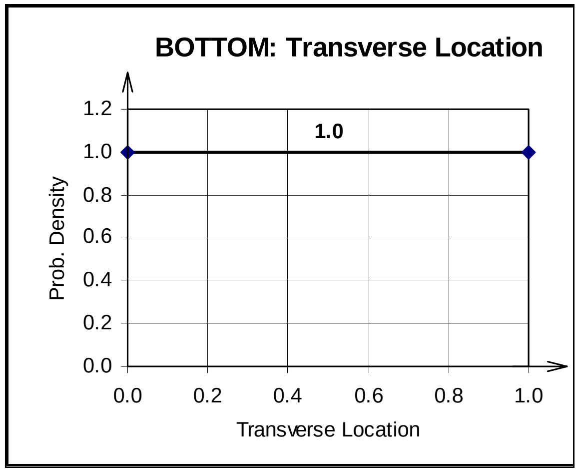


Figure 10

Based on the damage extents and locations covered by the density functions, a complete set of compartment groupings is developed. Each compartment group represents those tanks which can be breached from a given combination of damage location, length and penetration.

Application of the probability density functions for damage extent and location to these groupings provides the probability of occurrence of each damage incident. The cumulative probability of occurrence of all the damage incidents defined in this way is 1.0.

Compartment groupings and associated probabilities are developed by applying the distribution functions against the vessel compartmentation. This was performed using the HEC software package HECSALV.

Compartment groupings were developed by "stepping" through the vessel at the following increments. HEC performed the calculations on behalf of IMO to determine the outflow parameters for the reference ships presented in the IMO Guidelines. These same increments were applied when developing the outflow parameters for those reference ships.

For Side Damage:
- Longitudinal location at .01L
- Longitudinal length at .01L
- Transverse extent at .001B
- Vertical location at .01D
- Vertical extent at .01D

For Bottom Damage:
- Longitudinal location at .01L
- Longitudinal length at .01L
- Vertical extent at .001D
- Transverse extent at .01B
- Transverse location at .01B

C) Compute Oil Outflow

C1) Computing the Equilibrium Condition for Each Damage Case:

For the “Survivability” analysis only, calculations are run on each tank grouping (each damage incident). The analysis is performed using HEC Salvage Engineering Software (HECSALV), which has capabilities for evaluating both free-floating and stranded damaged conditions.

For each damage case, calculations are performed to determine the equilibrium condition and residual stability in the fully loaded condition. For free floating damage conditions, the damaged GZ curve is developed by performing iterative calculations at a series of heel angles until displacement and trim are in equilibrium. Heeling arms are developed at 10 degree increments using the "lost buoyancy" approach. Intermediate GZ values are developed by cubic spline interpolation.

Survivability for free-floating damaged conditions is based on a comparison with the MARPOL'73 criterion. These limits are as follows:

> <u>Equilibrium Heel Angle</u>: Maximum 25 degrees if the deck edge is immersed. Otherwise, a maximum of 30 degrees.
>
> <u>Righting Arm</u>: Maximum residual righting lever of at least 0.1 meters.
>
> <u>Range of Positive Stability</u>: Range of positive stability beyond the equilibrium heel angle of at least 20 degrees.
>
> <u>Progressive Downflooding</u>: Downflooding points such as overflows and air pipes for all non-breached compartments shall not be immersed at the equilibrium waterline.
>
> Note: Critical downflooding points limiting the equilibrium heel angle are the ballast tank overflows, which are taken as 600 mm above the main deck at side.

For bottom damage cases, stranding calculations are carried out based on a depth of water equal to the intact drafts. The HECSALV software has capabilities for evaluating strandings on one pinnacle, two pinnacles, or a shelf. For the analyses of strandings in this study, it is assumed that the vessel was stranded on a shelf extending over 80% of the length of the vessel. If the vessel is found to be free-floating due to outflow of oil, free-floating calculations are performed and the results are applied in lieu of the stranding calculations. If, due to outflow, one end of the vessel lifts off the shelf, single point contact is assumed at the other end of the shelf and iterative calculations are performed to determine the final trimmed waterline. It is assumed that the vessel is aground over her full beam, and that the ground contact restricts heeling of the vessel.

C2) Computing the Oil Outflow for Each Damage Case:

<u>“Conceptual” Analysis</u>: With this approach, the vessel is assumed to survive all incidents. The outflow for each side damage case is simply the sum of the volumes of oil carried in each damaged oil tank. For bottom damage, the outflow is based on a pressure balance calculation, assuming the vessel remains aground with zero trim and heel.

<u>“Survivability Analysis”</u>: Once the equilibrium condition has been determined, the quantity of oil outflow can be calculated. If the damage case fails to meet damage stability survivability criteria, the ship is assumed lost and 100% of all cargo oil on board is taken as "outflow". For side damage cases which survive, all the oil is assumed to flow out of breached tanks. For bottom damage cases, oil is assumed to flow out of breached tanks into the sea (or double bottom "capture" tanks)

until hydrostatic pressure equilibrium is achieved. The computed oil outflows for all affected tanks are summed to determine total outflow for that particular damage case.

For oil outflow estimation purposes the top of the damage is chosen to be at the inboard, bottom of the tank, at the aft bulkhead for tanks forward of amidships and at the forward bulkhead for tanks aft of amidships.

In its final equilibrium condition, each breached compartment is assumed to be in free communication with the sea. At the damage opening, the internal pressure exerted by the oil and flooded water and inert gas pressure within the tank will equal the external pressure exerted by the sea water. It is assumed that the inert gas system exerts a positive pressure of .05 bar as specified in the "Guidelines".

Consistent with the "Guidelines", for bottom damage cases it is assumed that the flooded volume of the double bottoms would retain a 50:50 ratio of oil:seawater. The "capture" of oil by the double bottom tanks applies only if a cargo oil tank immediately above the damaged double bottom is also breached.

D) Compute the Oil Outflow Parameters

Once all possible damage combinations have been evaluated, they are placed in descending order as a function of oil outflow. A running sum of probabilities is computed, beginning at the minimum outflow damage case and proceeding to the maximum outflow damage case. This "cumulative probability" can then be plotted against oil outflow (see Figure 11).

The cumulative probability of oil outflow plot provides a picture of a vessel's ability to resist oil spillage when damaged. On the sample plot , Figure 11, the oil outflow corresponding to a cumulative probability of 0.8 is 30,000 m^3. This means that in 80% of all collisions or groundings, the outflow will not exceed 30,000 m^3. It therefore follows that 20% of all damage incidents will have outflows in excess of 30,000 m^3. (Note: Figure 11 is for illustrative purposes only, and does not represent the outflow characteristics of the subject vessels.)

Independent oil outflow tables are developed for side and bottom (grounding) damage. The three outflow parameters (the probability of zero outflow, mean outflow and extreme outflow) are then computed as explained below. Bottom damage calculations are run for 0.0m, 2m and 6m (or one-half the draft, whichever is less) tidal changes, and combined by applying weighing factors of 40%, 50% and 10% respectively. The side damage and bottom damage results are combined by applying weighing factors of 40% and 60% respectively.

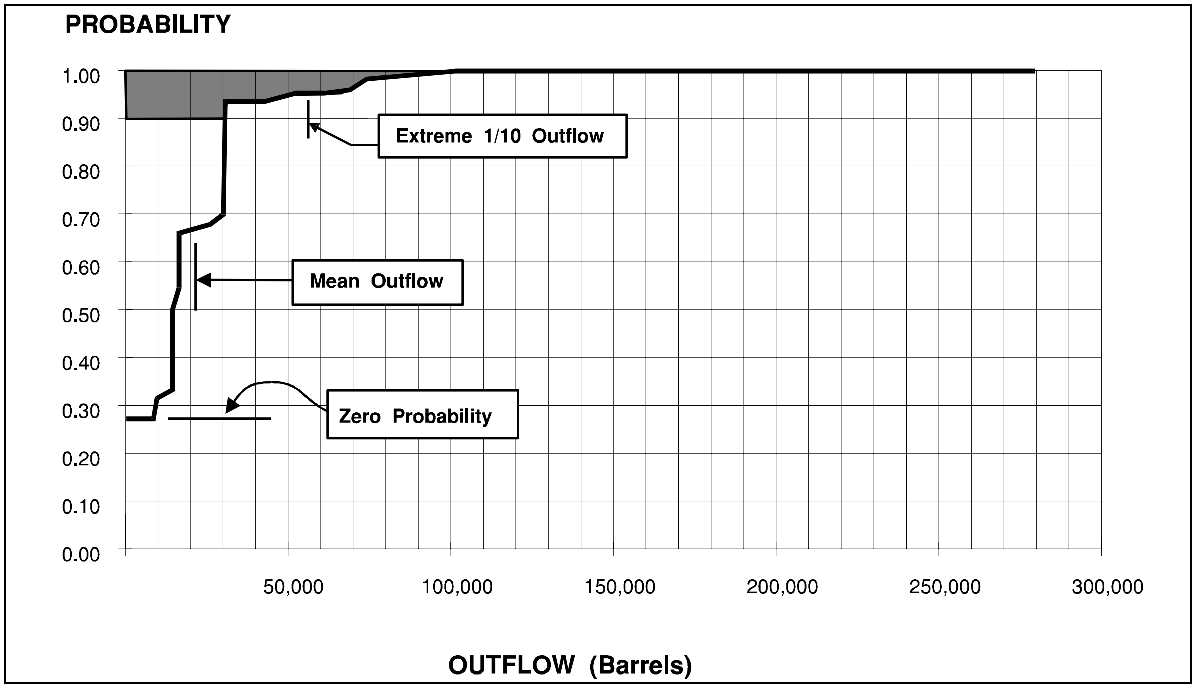


Figure 11 Cumulative Probability Of Oil Outflow

The three oil outflow parameters are labeled in Figure 11 and described below.

> Probability of Zero Outflow: This parameter represents the probability that no oil will be released into the environment. For the vessel depicted in Figure 11, the probability of zero outflow is 0.28. That is, there will be no oil outflow in 28% of all casualties. Conversely, 72% of all collisions or strandings will result in some level of oil outflow.
>
> Mean Outflow: The sum of the products of each damage case probability and the computed outflow for that damage case yields the mean (expected value) of oil outflow.
>
> Extreme (1/10) Outflow: This value represents the "worst case" spill scenario, and is a weighted average of the upper 10% of all casualties. The products of each damage case probability with a cumulative probability between 0.90 and 1.0 and its corresponding oil outflow are summed, and the result divided by 0.10.

E) Compute the Pollution Prevention Index "E"

The oil pollution prevention index "E" is computed in accordance with paragraph 4.2 of the *Guidelines*. To attain equivalency to the double hull reference "rule" design, the index "E" must be greater than or equal to 1.0.

$$E = \frac{(0.5)(P_O)}{P_{OR}} + \frac{(0.4)(0.01 + O_{MR})}{0.01 + O_M} + \frac{(0.1)(0.025 + O_{ER})}{0.025 + O_E}$$

where:

P_O = parameter for probability of zero outflow for the alternative design

O_M = mean oil outflow parameter for the alternative design. This equals the mean oil outflow divided by the total cargo oil capacity at 98% tank filling.

O_E = extreme oil outflow parameter for the alternative design. This equals the extreme oil outflow divided by the total cargo oil capacity at 98% tank filling.

P_{OR}, O_{MR} and O_{ER} are the corresponding parameters for the reference or “rule” double hull design of the same cargo oil capacity.

U.S. Department of Transportation
United States Coast Guard

Memorandum

Subject:	OPA 90 DOUBLE HULL EQUIVALENCY DETERMINATIONS: OIL OUTFLOW ANALYSIS METHODOLOGY	Date:	August 6, 2001 9070/1 16703/NVIC 10-94 16703/M16000.7/D.6
From:	G-MSE-2		
To:	Memo to File	Reply to Attn. of:	G-MSE-2 J. Person J. Sirkar

1. This memo documents the oil outflow analysis methodology we will accept for making OPA 90 double hull equivalency determinations. A double hull equivalency is normally requested only when a double hull tank vessel built prior to June 30, 1990, (that is, a "pre OPA 90" double hull) does not fully comply with the OPA 90 double hull dimensions specified in 33 CFR 157.10d.

2. The premise behind a double hull equivalency determination is that we allow a trade-off of the negative consequences of an undersized double bottom or side dimension for the benefits of an oversized double bottom or side dimension, provided both the following conditions are satisfied: (1) The overall oil outflow performance ("E") of the as-built vessel is equal or better than that of a reference (or "rule") comparably sized "post OPA 90" double hull tank vessel, and (2) The probability of zero outflow performance ("P_0") of the vessel is equal or better than that of a reference (or "rule") comparably sized "pre OPA 90" double hull.

3. Both "E" and "P_0" should be calculated using the methodology contained in IMO Resolution MEPC.66(37), "Interim Guidelines for the Approval of Alternative Methods of Design and Construction of Oil Tankers Under Regulation 13F(5) of Annex I of MARPOL 73/78". To meet the 2 conditions noted in above paragraph 2., the reference (or "rule") double hull(s) that should be used are described below.

   a. For comparing the overall oil outflow performance (E") of the as-built vessel to that of the "rule" double hull, the "rule" double hull should be an equivalent sized tank vessel with the same cargo capacity as the as-built double hull, and internal cargo tank compartmentation consistent with the appropriately interpolated reference double hull as defined in the above mentioned MEPC.66(37), but having double hull dimensions conforming to the requirements in 33 CFR 157.10d(c)(1)(i) or (ii) and 157.10d(c)(2)(i) or (ii), as appropriate for the DWT. That is, the double side and double bottom dimensions of the "rule" double hull should conform to that of a "post OPA 90" vessel.

b. For comparing the probability of zero oil outflow ("P_0") of the as-built vessel to that of the "rule" double hull, the "rule" double hull should be an equivalent sized tank vessel with the same cargo capacity as the as-built double hull, but having double hull dimensions conforming to the requirements in 33 CFR 157.10d(c)(1)(iii) and 157.10d(c)(2)(iii). That is, the double side and double bottom dimensions of the "rule" double hull should conform to that of a "pre OPA 90" vessel.

4. A related matter is verification of the vessel's double hull dimensions to those used in the oil outflow analysis that form the basis of the double hull equivalency determination. The consistency of these dimensions must be demonstrated to the satisfaction of the cognizant Coast Guard Officer-in-Charge, Marine Inspection (OCMI) at the vessel's next Tank Vessel Examination.

H. Paul Cojeen

H. PAUL COJEEN

APPENDIX 4:
PRESENTATIONS AT PUBLIC MEETINGS

Following is a copy of the presentation made at a public meeting of stakeholders. Revisions made as a result of comments during the presentation are highlighted in yellow.

THE GLOSTEN ASSOCIATES
Consulting Engineers Serving the Marine Community

Study of Tug Escort for Laden Tankers Interim Presentation

Presented to The Department of Ecology Spills Program
Oil Spill Advisory Committee
3 November 2004

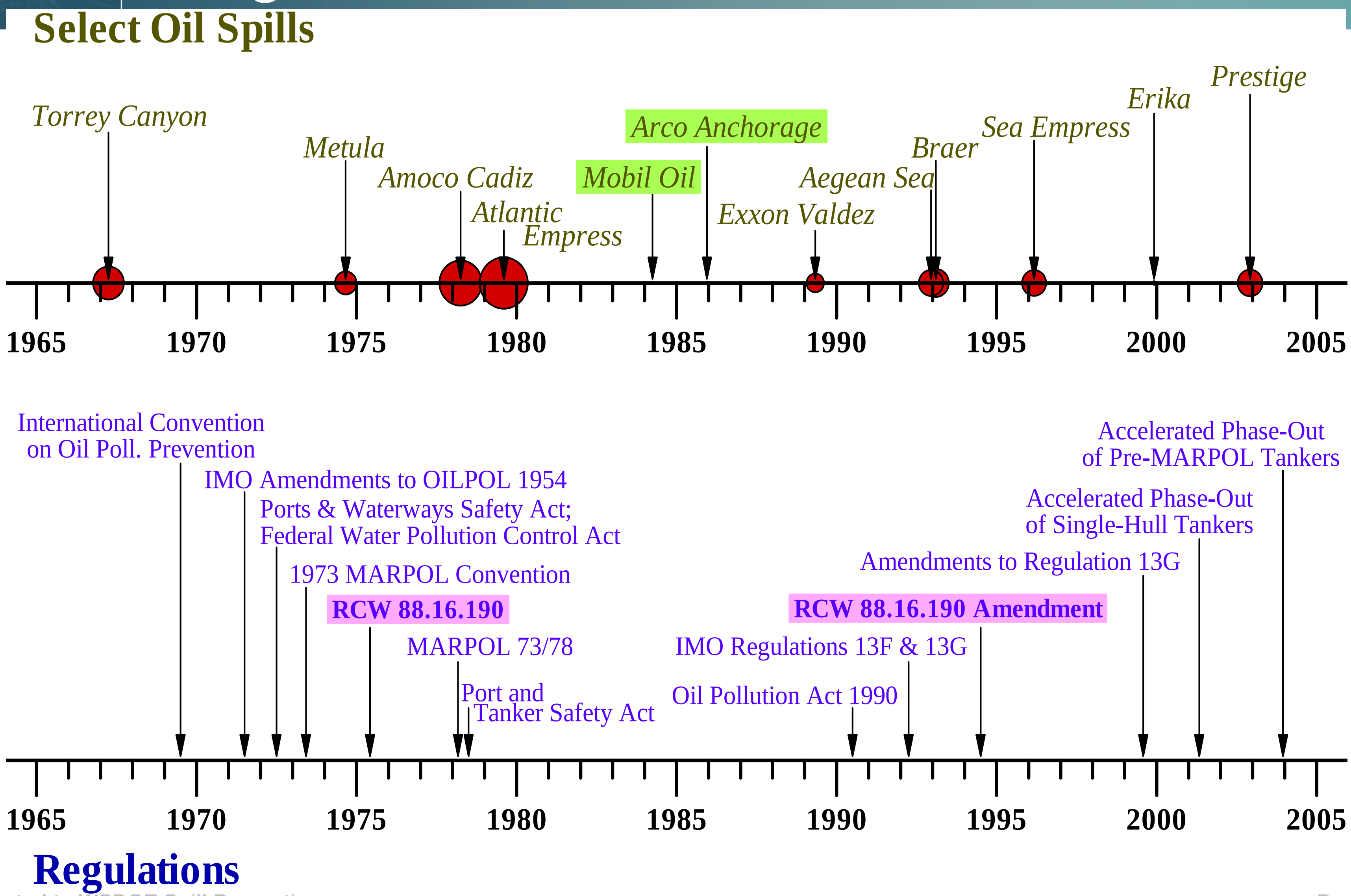
Outline of Presentation

1. History of Tanker of Escort Regulations
2. RCW 88.16.190
3. OPA 90
4. Tanker Escort in other Locations
5. Socioeconomic Costs
6. Phase out of Single Hull Tankers
7. Tanker Hull Structure
8. Escort Maneuvers
9. Capabilities of Escort Tugs
10. Escort with RCW Minimum Compliance Tug
11. Probability of Grounding
12. Oil Outflow Calculation
13. Preliminary Conclusions

Comments, Additions, Edits and Corrections from the 3 November presentation are highlighted in yellow.

There will be a chapter in the final report discussing additional capabilities of escort tugs, including auxiliary navigation (scouting), firefighting and first response oil spill containment.

History of Oil Spills & Oil Trade Regulations



RCW 88.16.190

Regulations entered force in 1975 (last amended 1994):

1. Oil tankers > 125,000 DWT prohibited beyond east of line from Discovery Island light south to New Dungeness light
2. Oil tankers of 40,000 to 125,000 DWT required to have <u>all</u> of the following standard safety features (minimum compliance), to proceed east of above line:
   – Shaft horsepower ratio of 1 hp to each 2-½ dwt (*50,000 hp for 125,000 dwt*)
   – Twin screws
   – Double bottoms underneath all oil and liquid cargo compartments
   – Two radars (one a collision avoidance radar) in working order & operating
   – Other navigational aids as prescribed by board of pilotage commissioners

OR: Transit in ballast or under escort of tug(s) having aggregate shaft horsepower equivalent to 5% of DWT tons of tanker (*6,250 hp for 125,000 dwt*)

Issues with RCW 88.16.190

OPA 90 does not require escort of double-hull tankers;
These vessels are subject only to RCW 88.16.190.

1. Is RCW 88.16.190 a reasonable requirement for double-hull tankers with redundant systems (twin-screw, twin-rudder)?
2. Is the 5% rule for tug horsepower reasonable?
3. Is a performance requirement needed, based on transit speed, etc.?
4. Is a tug capability requirement needed (single screw, twin screw, tractor).?

The basis for comparing changes to escort for redundant system tankers is the level of oil outflow risk from a single screw double hull tanker with escort. This standard was provided to the study by the WSDOE and is presumed to be the level of risk acceptable under RCW 88.16.190. For this study acceptable risk is a single screw IMO minimally compliant double hull SuezMax (150,000 dwt) tanker with RCW minimally compliant escort tug is used to determine the maximum acceptable risk.

OPA 90

Performance requirements for escort vessels :

a) An operational requirement

- operate within the performance capabilities of its escorts
- taking into consideration its speed, ambient sea & weather conditions
- all factors that may reduce the available sea room

b) A set of minimum performance requirements :

- Towing;
- Stopping ~~(superseded)~~; suspended (OPA 90 does have a minimum braking performance requirement for an escort tug)
- Holding; and
- Turning.

Other Escort Practices: North America

Puget Sound:

- Escort required under OPA 90 & RCW 88.16.190
- 15 twin-screw tugs, 11 Voith and 2 Z-drive tractors available

Prince William Sound:

- Escort required under OPA 90 & 18 AAC 75 (Alaska Oil & Other Hazardous Substances Pollution Control)
- 18 AAC 75:
  - Approved oil discharge prevention/contingency plan required for all tank vessels & oil barges in Alaska waters
  - Agreed upon speed limit of 6 knots in Valdez Narrows and elsewhere
  - Closure condition wind speed at Hinchinbrook Entrance
- 3 Voith and 3 Z-drive tractors available

Other Escort Practices: North America

San Francisco Bay:

- Escort required under CCR 14.4.4.1 (Tank Vessel Escort Regulations – San Francisco Bay)
- CCR 14.4.4.1:
  - Escort tugs required for tank vessels carrying 5,000 LT or more of cargo oil
  - Zone-dependent braking force is fn(displacement); alt. compliance OK
  - Zone-dependent speed limit of 8 or 10 knots
  - Exemption for double-hull, redundant steering & propulsion, bow thruster, and federal compliant navigation system
- 10 twin-screw tugs, 2 Voith and 18 Z-drive tractors available

Tug escort is not required if these conditions are met. (Added URL link)

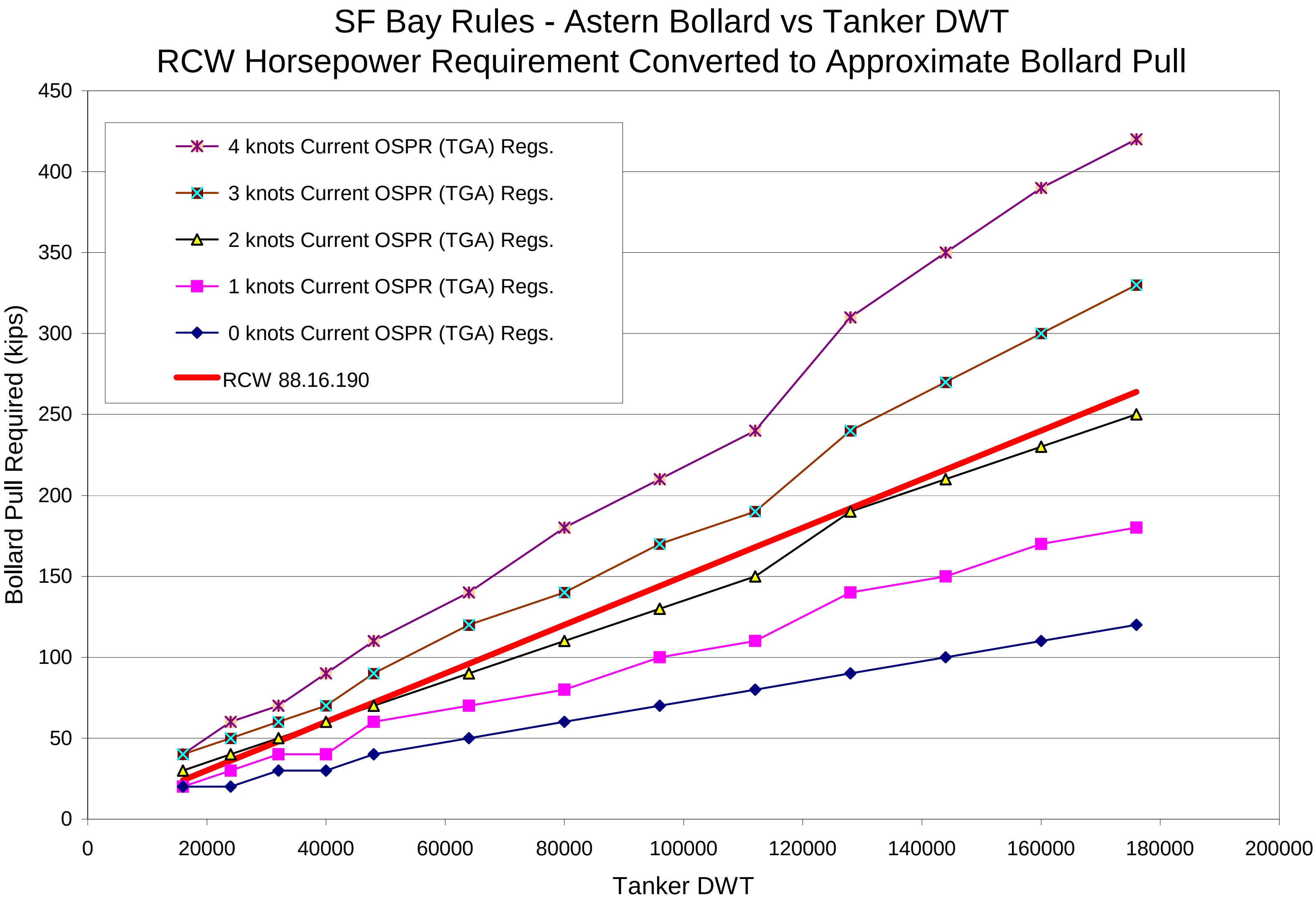
Other Escort Practices: North America

Los Angeles/Long Beach:

- Escort required under CCR 14.4.4.2 (Tank Vessel Escort Regulations – LA / LB Harbor)
- CCR 14.4.4.2:
  - Escort tugs required for tank vessels carrying 5,000 LT or more of cargo oil
  - Tug-type-dependent braking force is fn(tanker displ.); alt. compliance OK
  - Speed limit of 8 knots if < 60,000 t displacement; 6 knots if > 60,000 t displ.
  - Exemption requires double-hull, redundant steering & propulsion, bow thruster, and federal compliant navigation system
- 10 twin-screw tugs, 6 Voith and 8 Z-drive tractors available

Tug escort is not required if these conditions are met. (Added URL link)

Comparison of RCW and San Francisco Regulations



Other Escort Practices: North America

Whiffenhead, Newfoundland:

- Escort not required, but Newfoundland Transshipment Limited voluntarily practices two tug escort inbound/outbound laden tankers
- 2 Voith tractors available

Other Escort Practices: Europe

Mongstad and Rafsnes, Norway:

- Escort not required, but Port, Terminal Owners and Coastal Directorate voluntary practice escort tugs for inbound/outbound laden tankers
- More ports plan to start escorting
- 8 Voith and 13 Z-drive tractors available

Brofjorden and Gothenburg, Sweden:

- Escort not required, but Port, Terminal Owners and Coastal Directorate voluntary practice escort tugs for inbound/outbound laden tankers
- 1 Voith and 6 Z-drive tractors available

Other Escort Practices: Europe

Porvoo, Finland:

- Escort not required, but Port and Refinery Owner voluntary practice escort tugs for inbound/outbound laden tankers
- 2 Z-drive tractors available

Sullom Voe, Scotland;

Milford Haven, England

Liverpool, England:

- Escort not required, but Port and Terminal Owners voluntary practice escort tugs for inbound/outbound laden tankers
- Sullom Voe: 2 Voith tractors available;
  Milford Haven: 2 Z-drive tractors available;
  Liverpool: 5 Z-drive tractors available

Socioeconomic Costs / Impacts of an Oil Spill

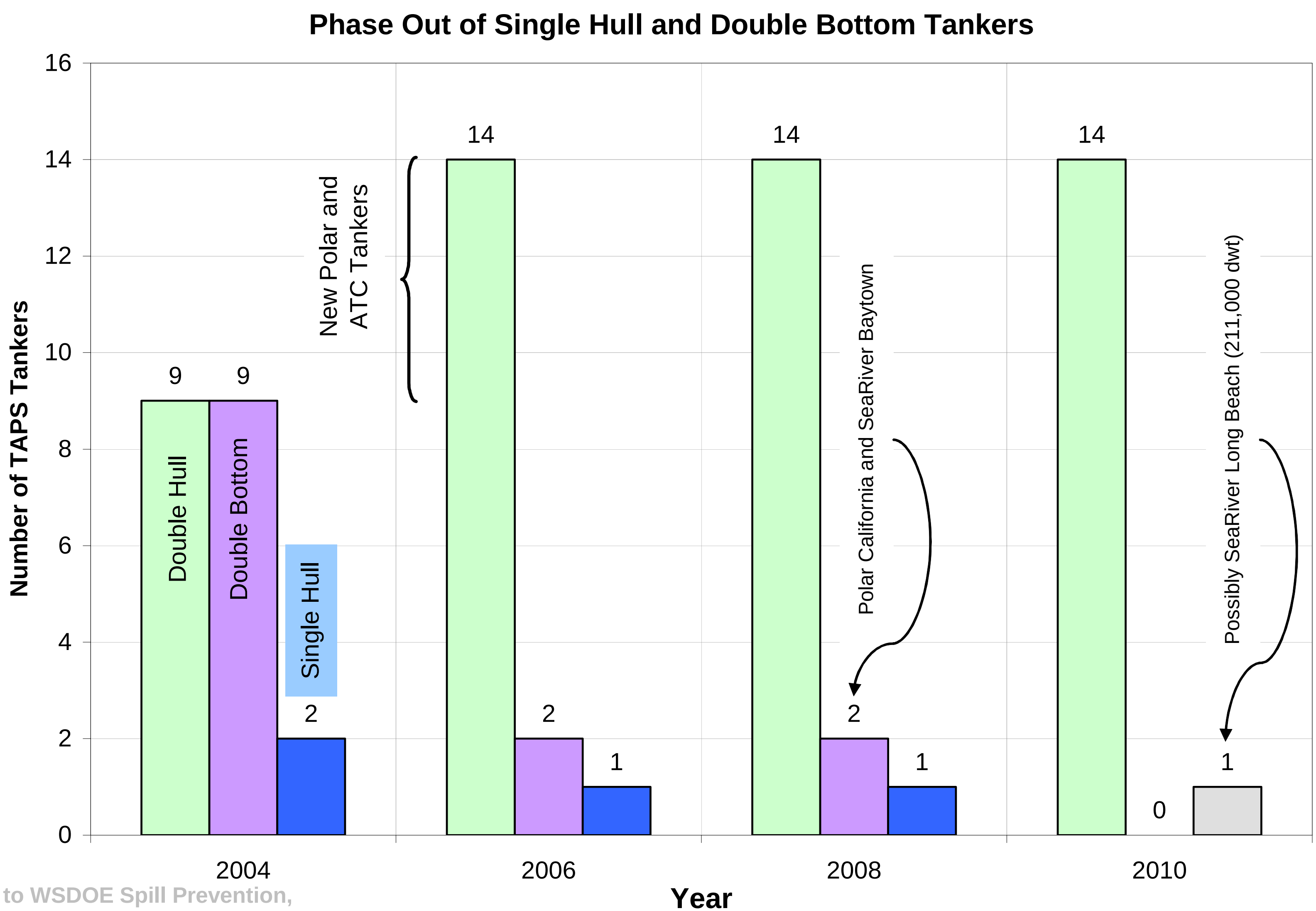
- Vessel blockage
- Port business disruption
- Commercial fishing
- Tribal fishing/shellfishing
- Shellfishing
- Recreational fishing
- National parks lost use
- State parks lost use
- Recreational boating
- National parks income
- State parks income
- Nature view income
- Marinas
- Tourism
- Tribal lands
- Cargo loss

Summary tables of value of resources protected will be developed and discussed in subsequent presentations and in the final report.

Response Cost Components

- Initial Mobilization ($500K)
- Management / Oversight ($4M - $8M)
- Salvage ($8M - $12M)
- Mechanical Equipment / Personnel
  - Days of oil slick (+ demobilize) X equipment / personnel cost
- Protective Boom ($2.84 M) per CAPS
- Dispersant Operations / Chemicals ($675K / $2.3M)
- Disposal (per bbl recovered + shoreline removal)
- Decontamination ($252 per bbl recovered)
- In Situ Burn Operations ($80/bbl burned to 1,500 bbl/day while oil >13 microns thick)

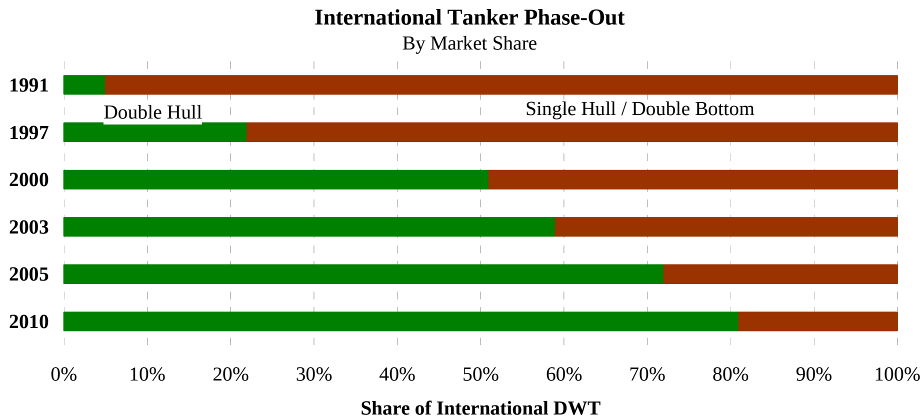
IMO MARPOL 73/78 2003 Amendment to 13G of Annex I (phase out all non double hull tankers by 2010*)

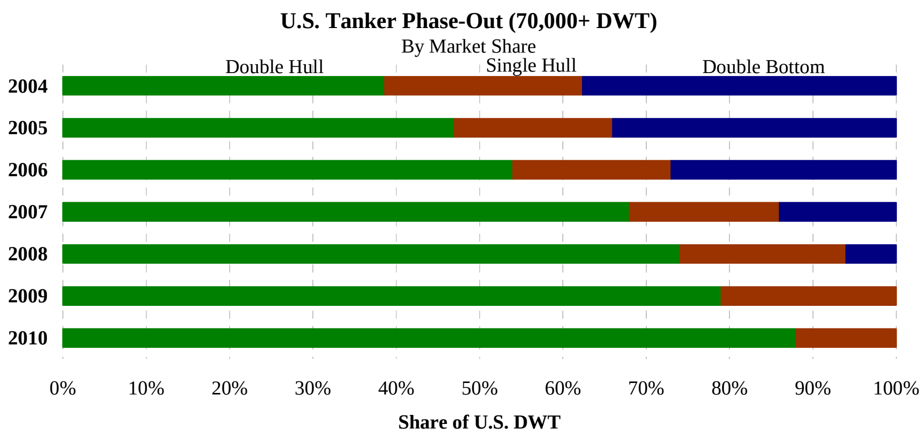


Phase Out all Non Double Hull Tankers by 2010

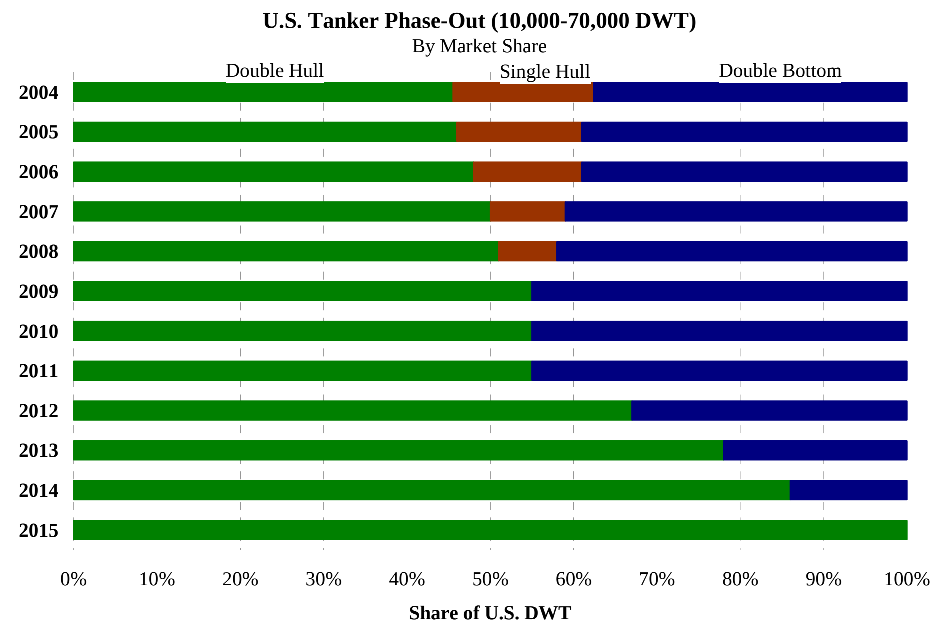
(New Slide)

(IMO MARPOL 73/78 2003 Amendment to 13G of Annex I)



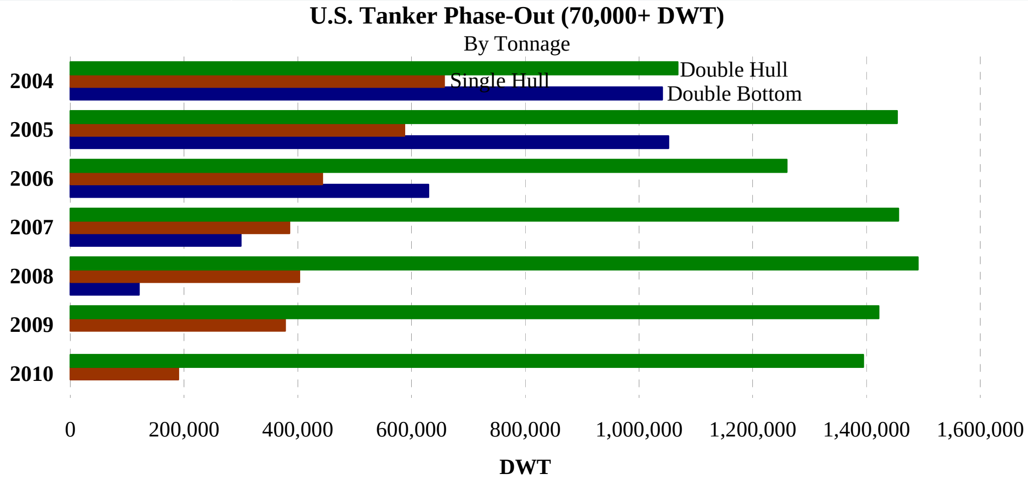


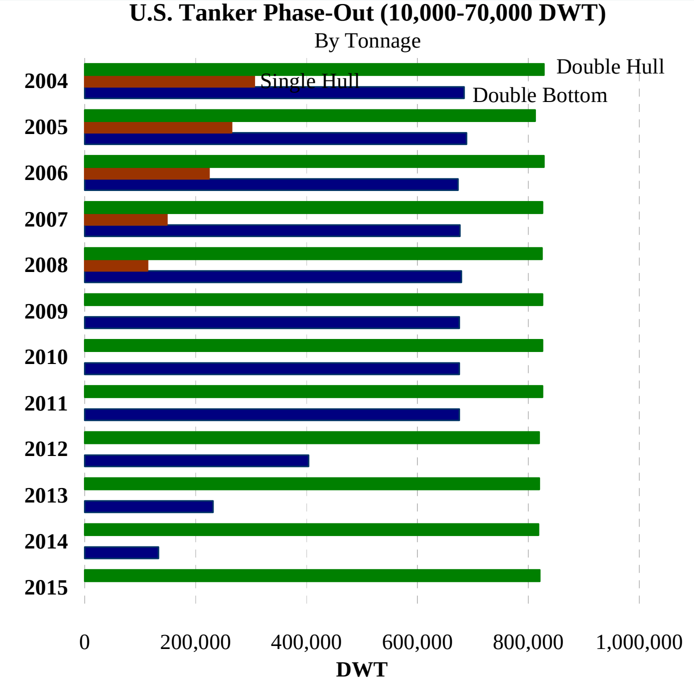
U.S. fleet phase out by 2015 proceeds in accordance with OPA 90.

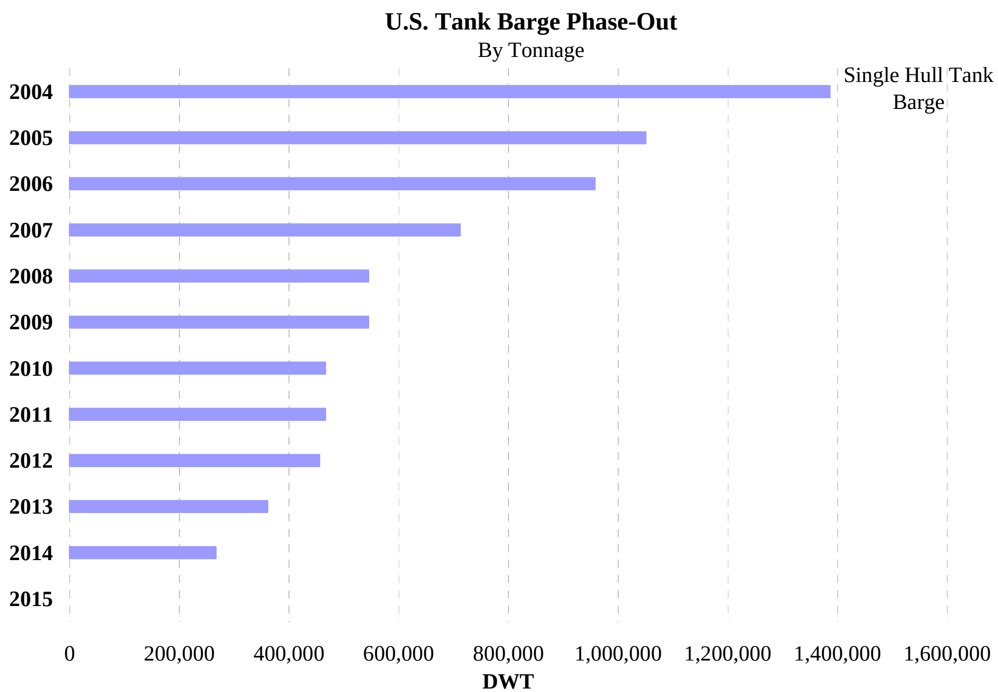


(New Slide)

Phase Out all Non Double Hull Tankers by 2015 (OPA 90)





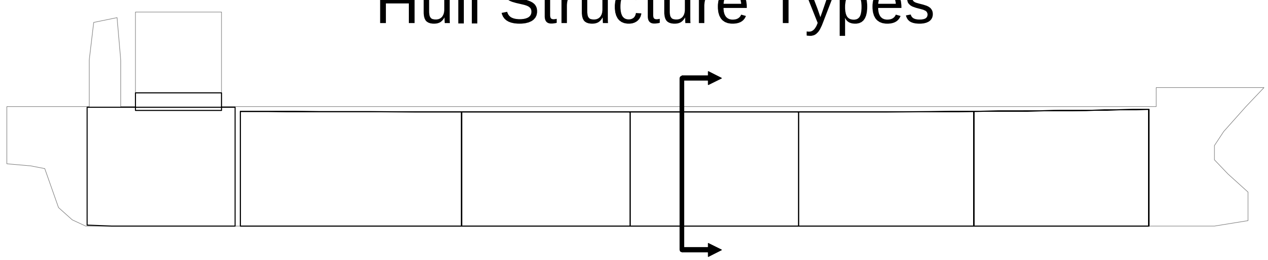


U.S. fleet phase out by 2015 proceeds in accordance with OPA 90.

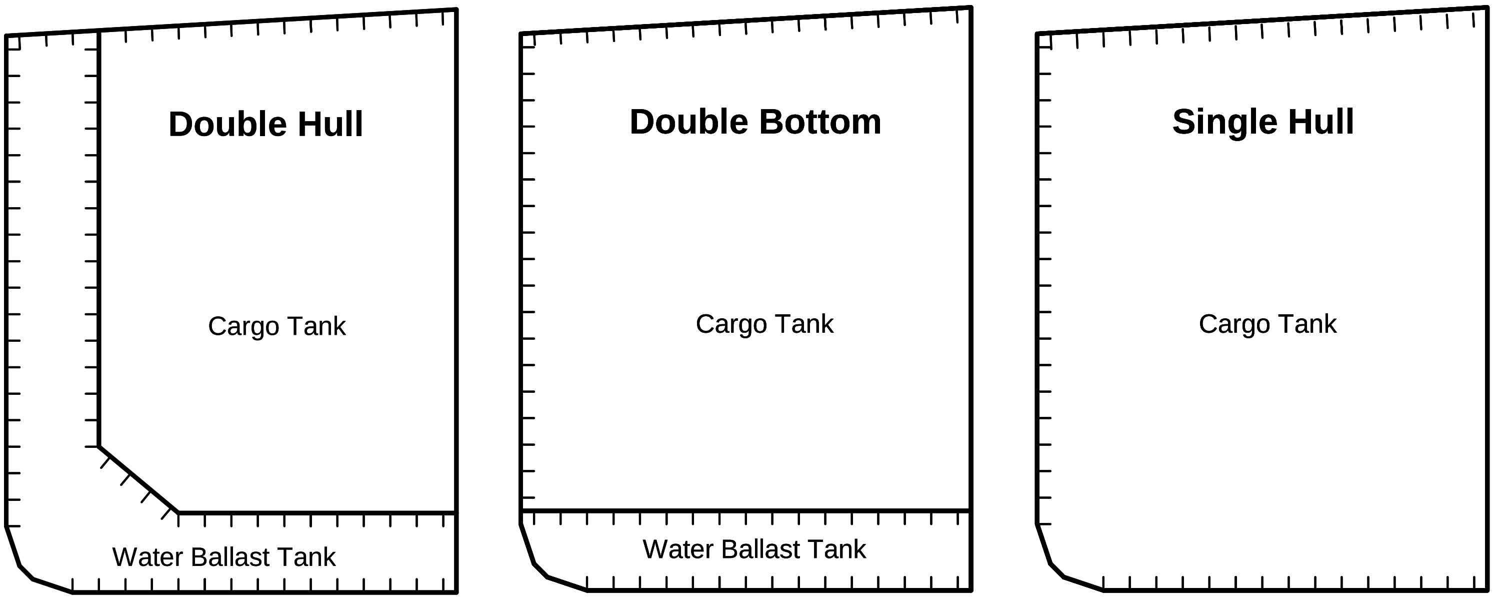
David Gray
The Glosten Associates, Inc
3 November 2004

Typical Single and Double Hull Structures

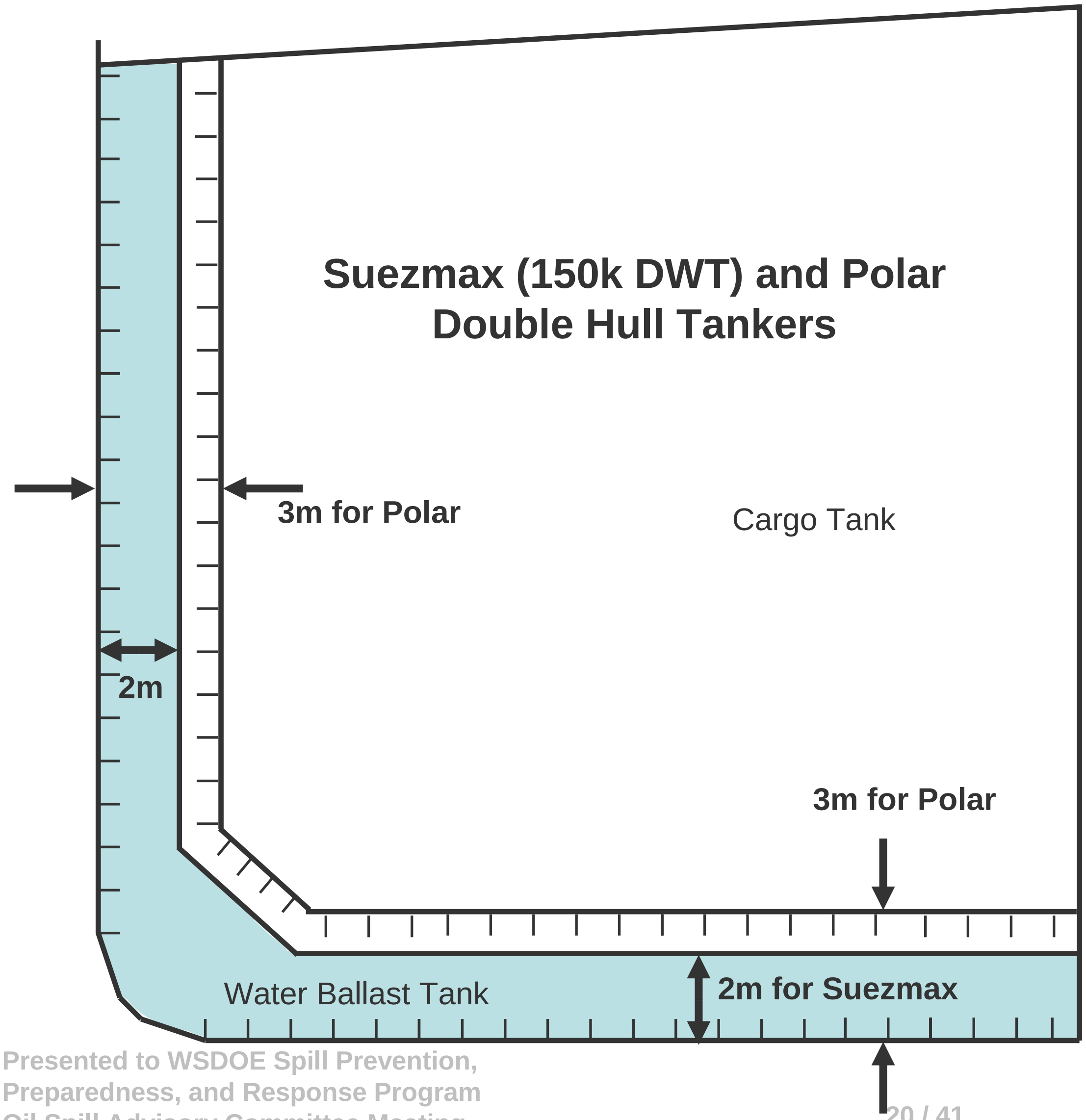
Hull Structure Types



Typical midship section of tankers entering Puget Sound



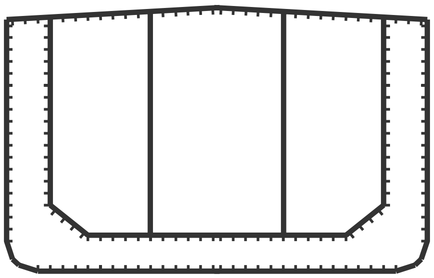
Typical and Polar Millennium Double Hull Spacing



Double Hull Dimensions
Suezmax = 2m*
BP ATC = 2.7m
Polar = 3.0m

* Future MARPOL regulations to be adopted in 2006 require oil outflow performance requirements.

- Approximately 2.5m double hull for 6x2 cargo arrgt.
- Approximately 2.3m double hull for 6x3 cargo arrgt.

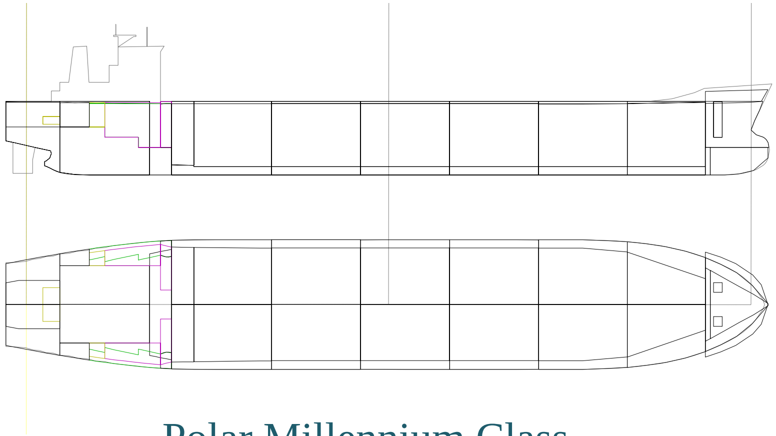


Loading of Polar and ATC Tankers

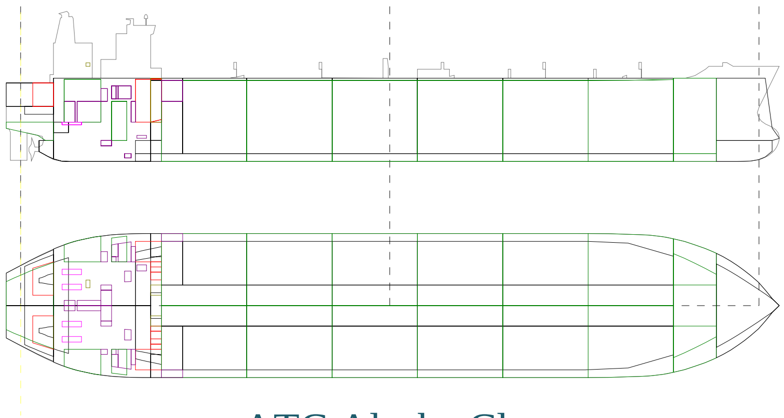
Polar Millennium Class is ~~148,000 dwt~~ 142,000 dwt

ATC Alaska Class is ~~188,000 dwt~~ 185,000 dwt

Each vessel is loaded to a 125,000 DWT for Puget Sound deliveries.
Tanks 2, 3, 4 and 6 loaded to 98%.
Tanks 1 loaded to 65%.
Tanks 5 loaded to 77%

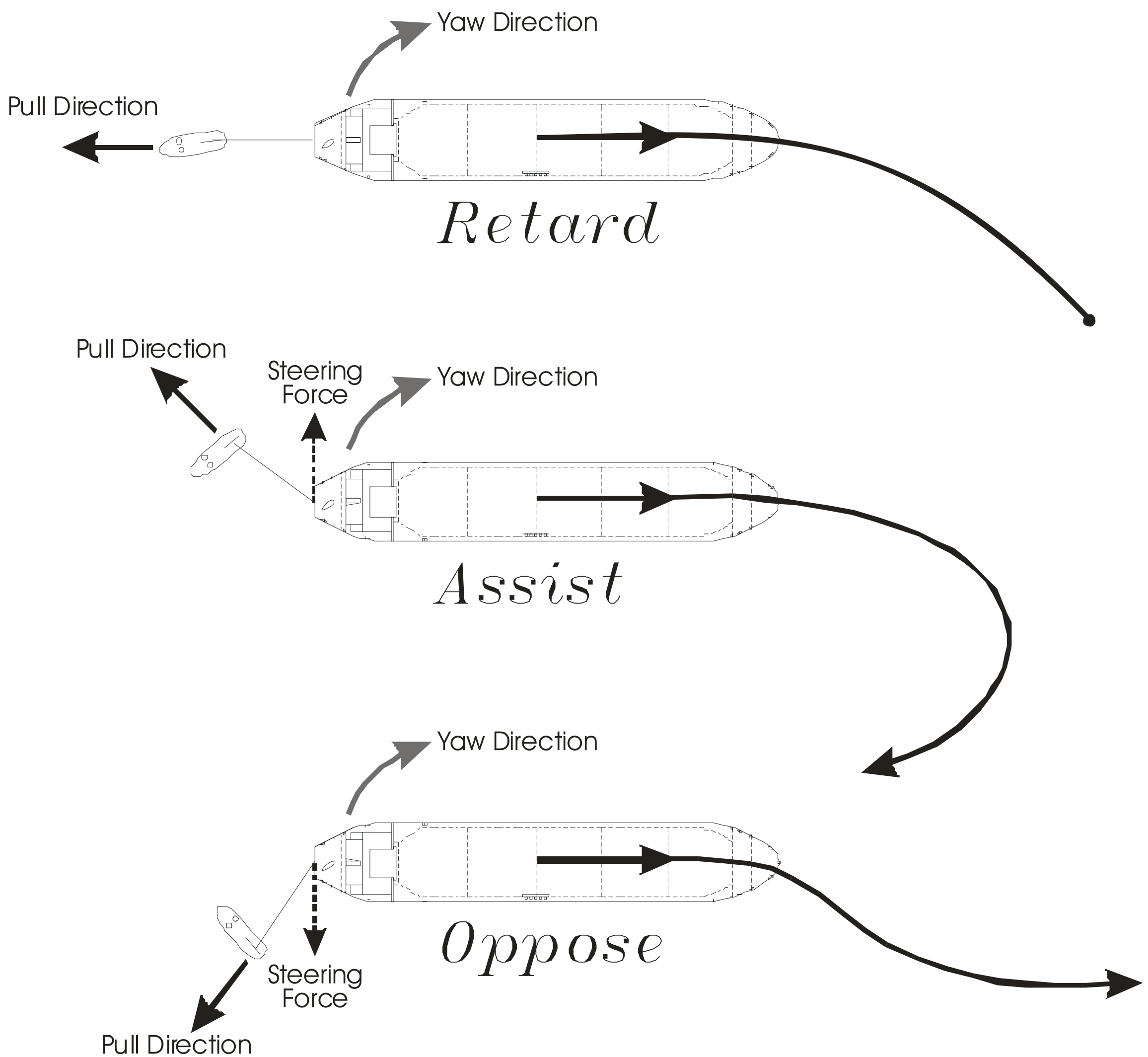


Polar Millennium Class

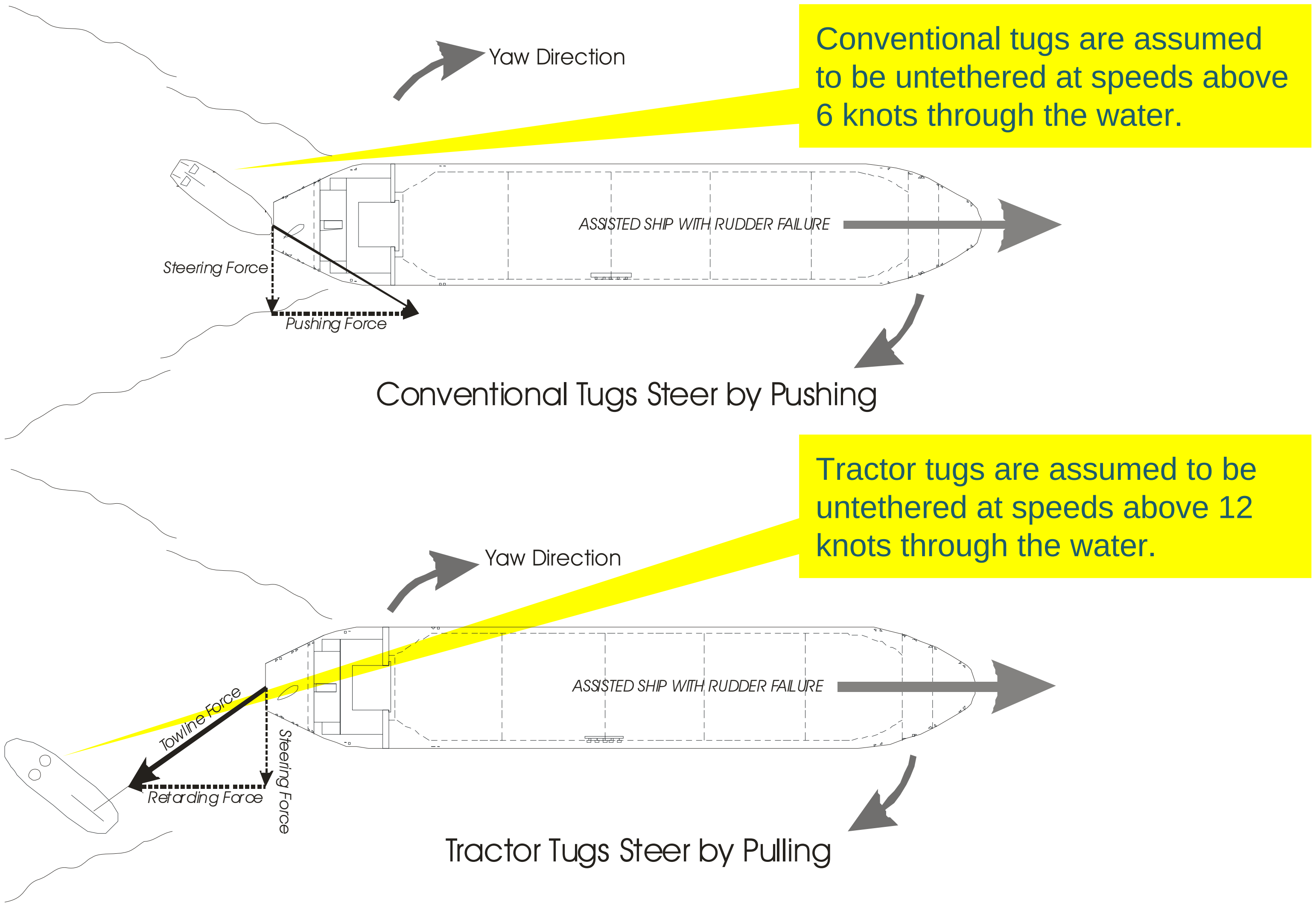


ATC Alaska Class

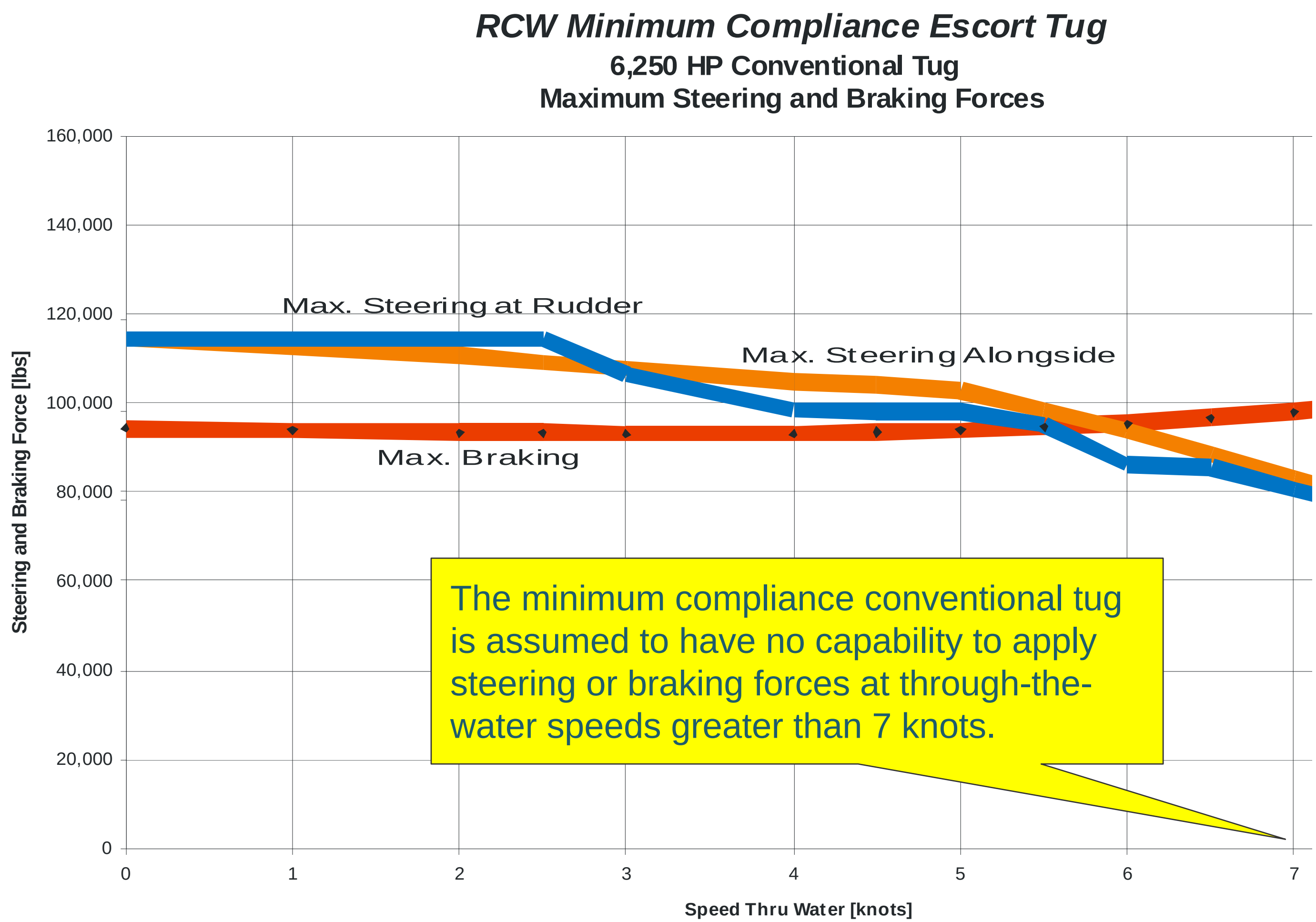
Escort Tug Emergency Response Maneuvers



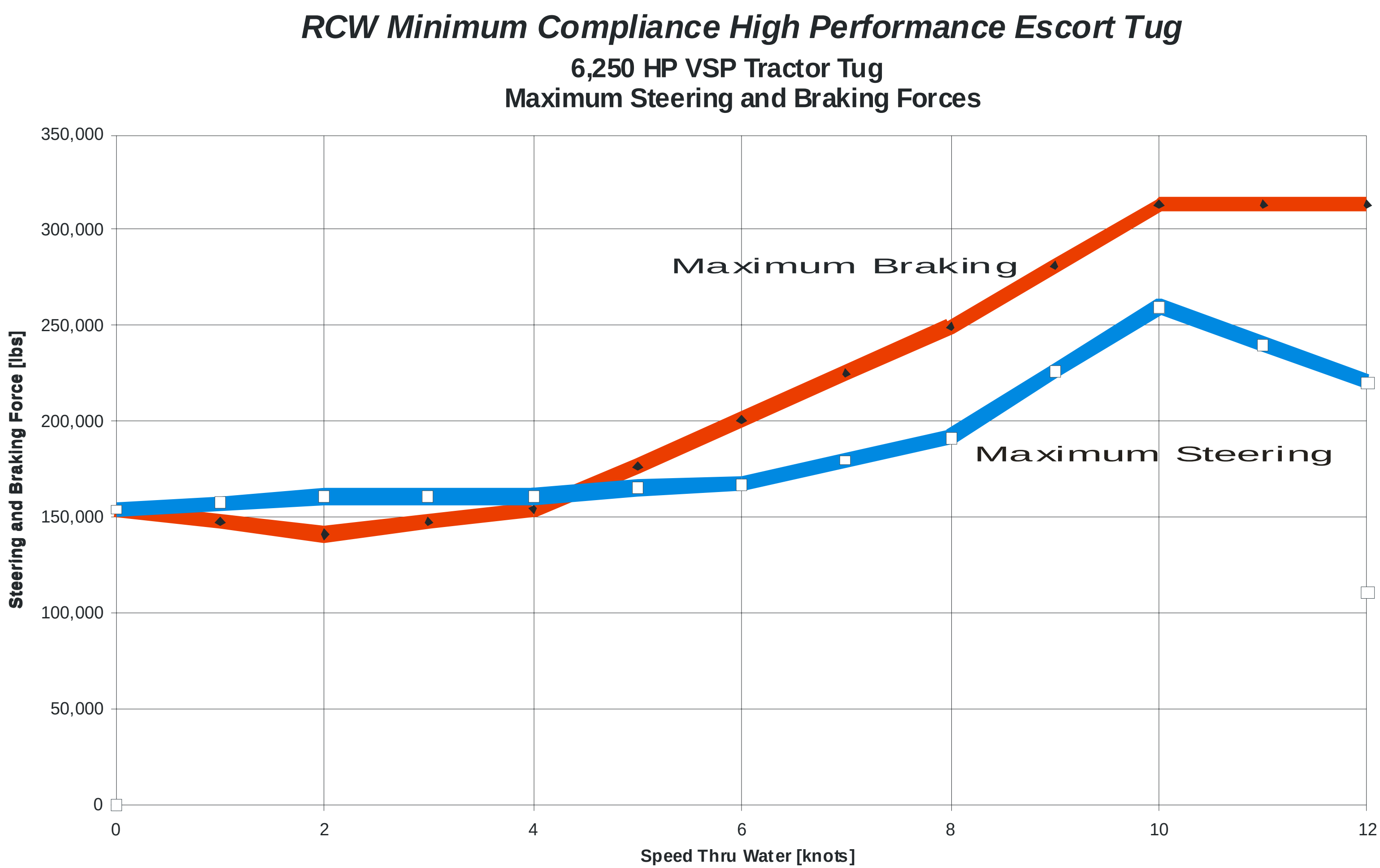
Comparing Conventional and Tractor Tug Emergency Response Maneuvers



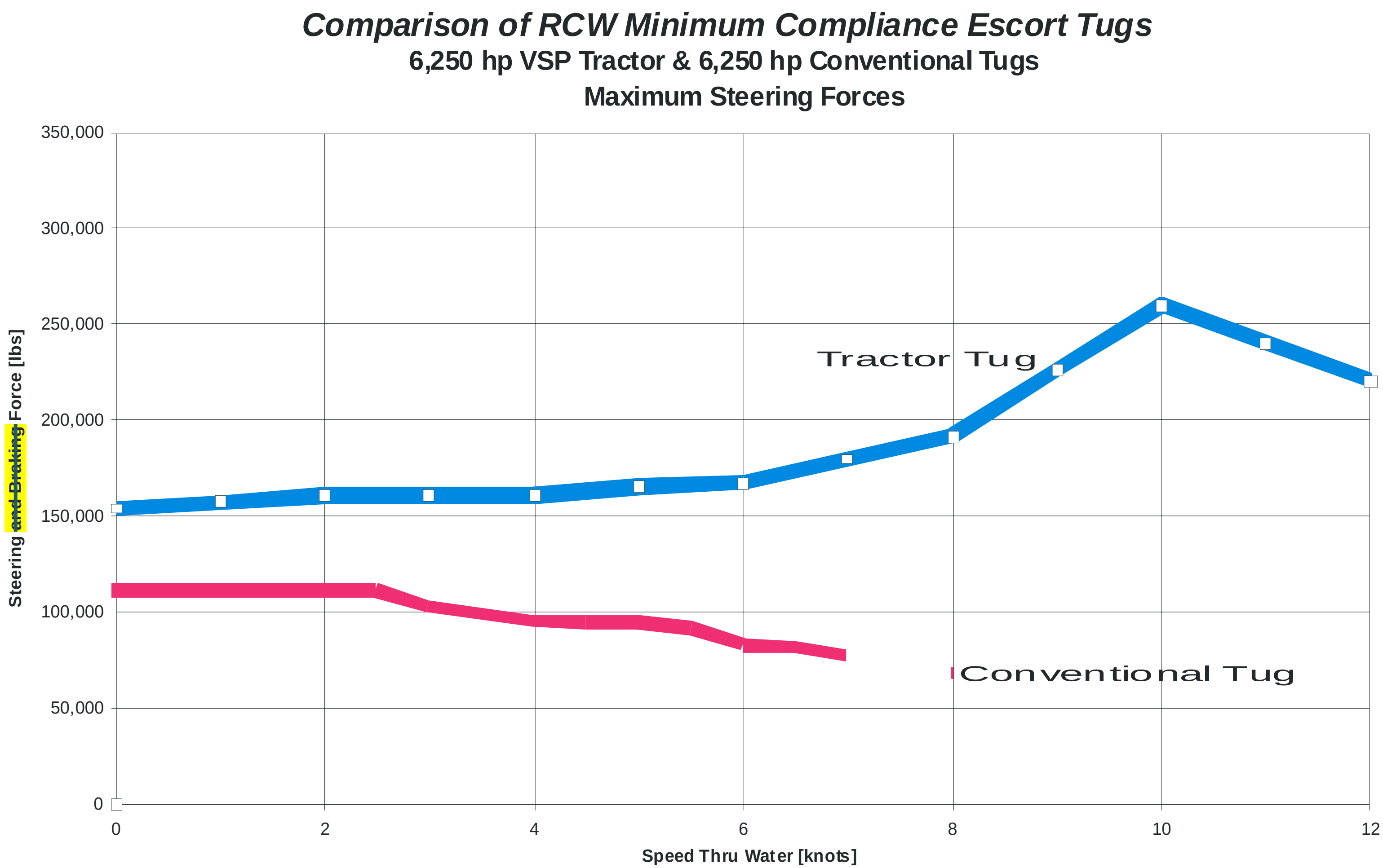
Capability of RCW Minimum Compliance Escort Tug



Capability of RCW Minimum Compliance High Performance Escort Tug



Comparison of RCW Minimum Compliance Escort Tugs



Escort with RCW Minimum Compliance Tug

Tanker Escort with RCW Minimum Compliance Tug & a Single Screw Tanker can be Successful in Preventing a Grounding

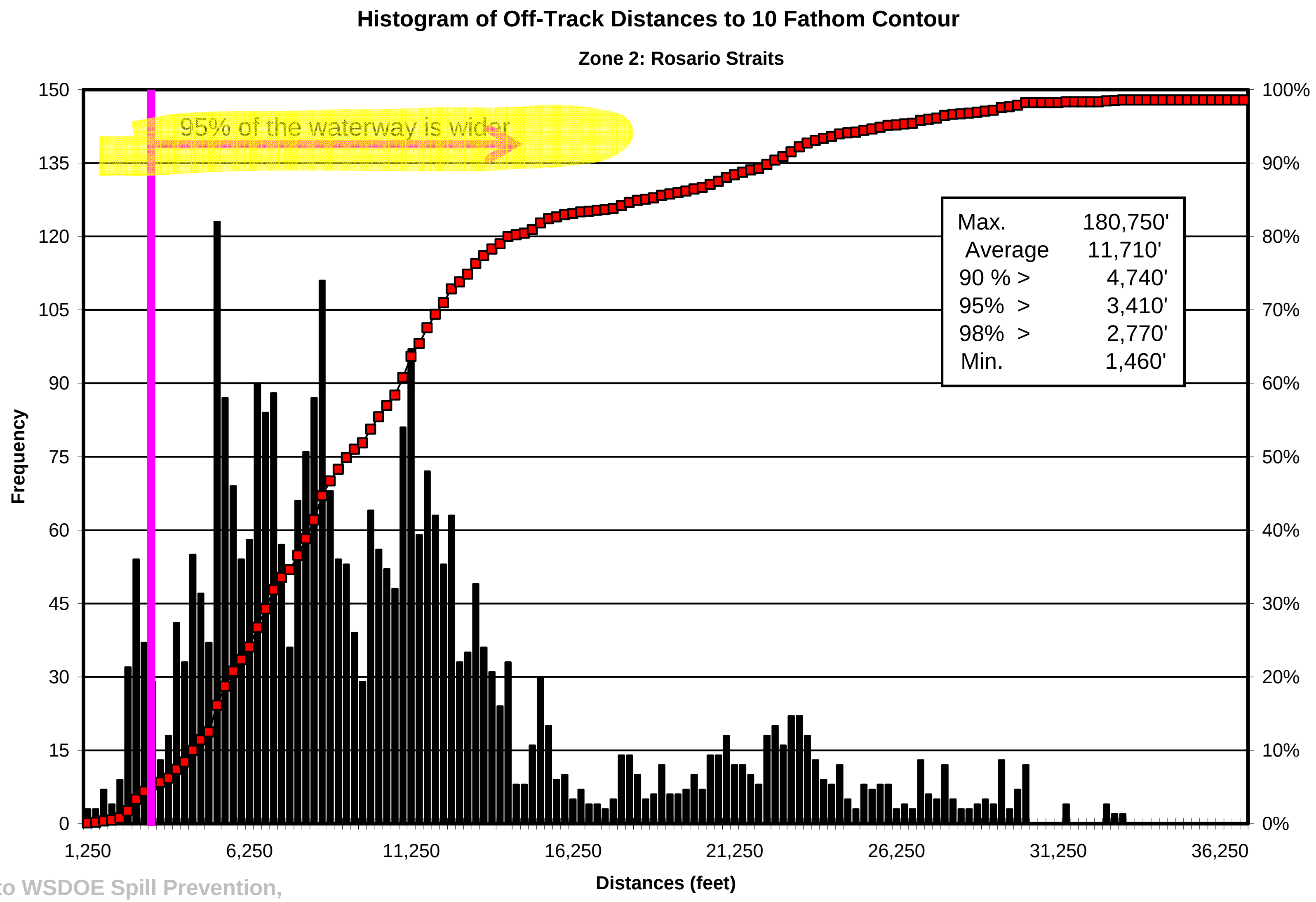
IF *(all of the following are implemented)*:

- Tanker is transiting at the appropriate speed for the waterway
- The failure occurs in the stretch of the waterway that is wider then the 95 %tile width or the tanker slows down to match the tug's capability during the narrower portion.
- Tanker propulsion is shutdown within 30 seconds of failure
- Failure condition is correctly understood within 60 seconds of failure
- The best corrective maneuver (out of three possible maneuvers) is chosen
  - The best corrective maneuver depends on tanker speed
  - The best corrective maneuver depends rudder failure angle
- Tug starts corrective maneuver within 120 seconds of failure
- The tug executes the corrective maneuver using maximum capability

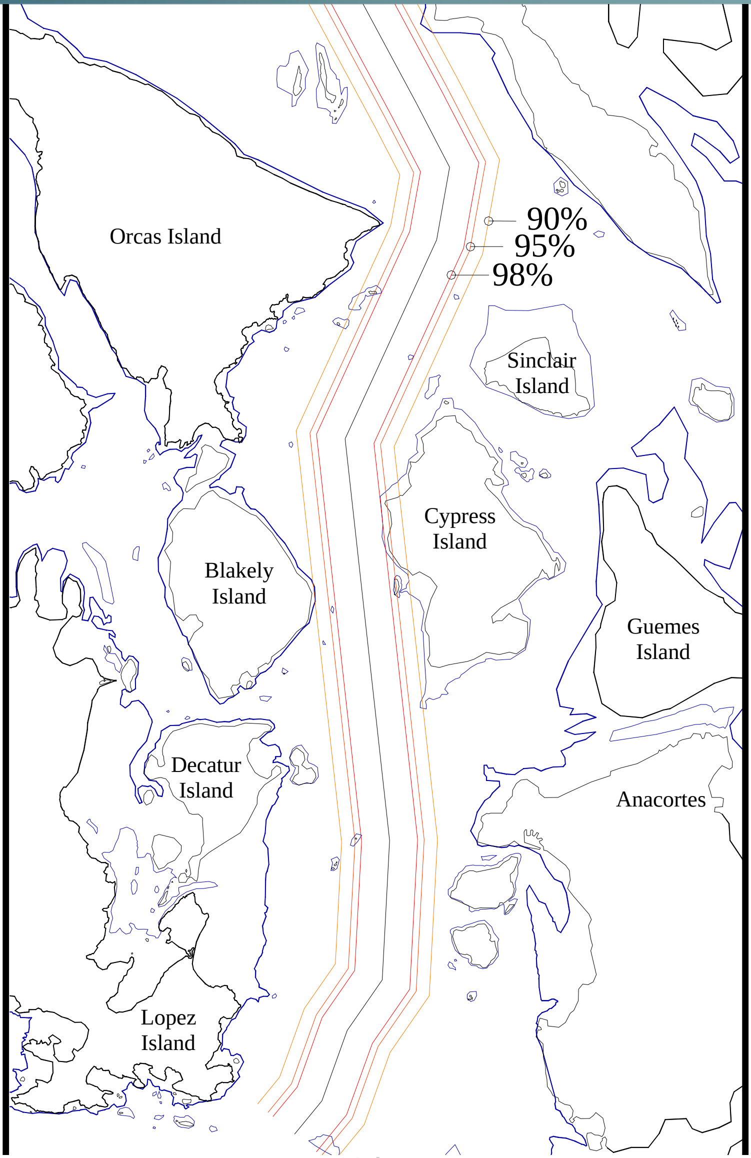
An Engineered Solution Exists that can Prevent a Grounding

However, Human Factors Govern the Probability of Success

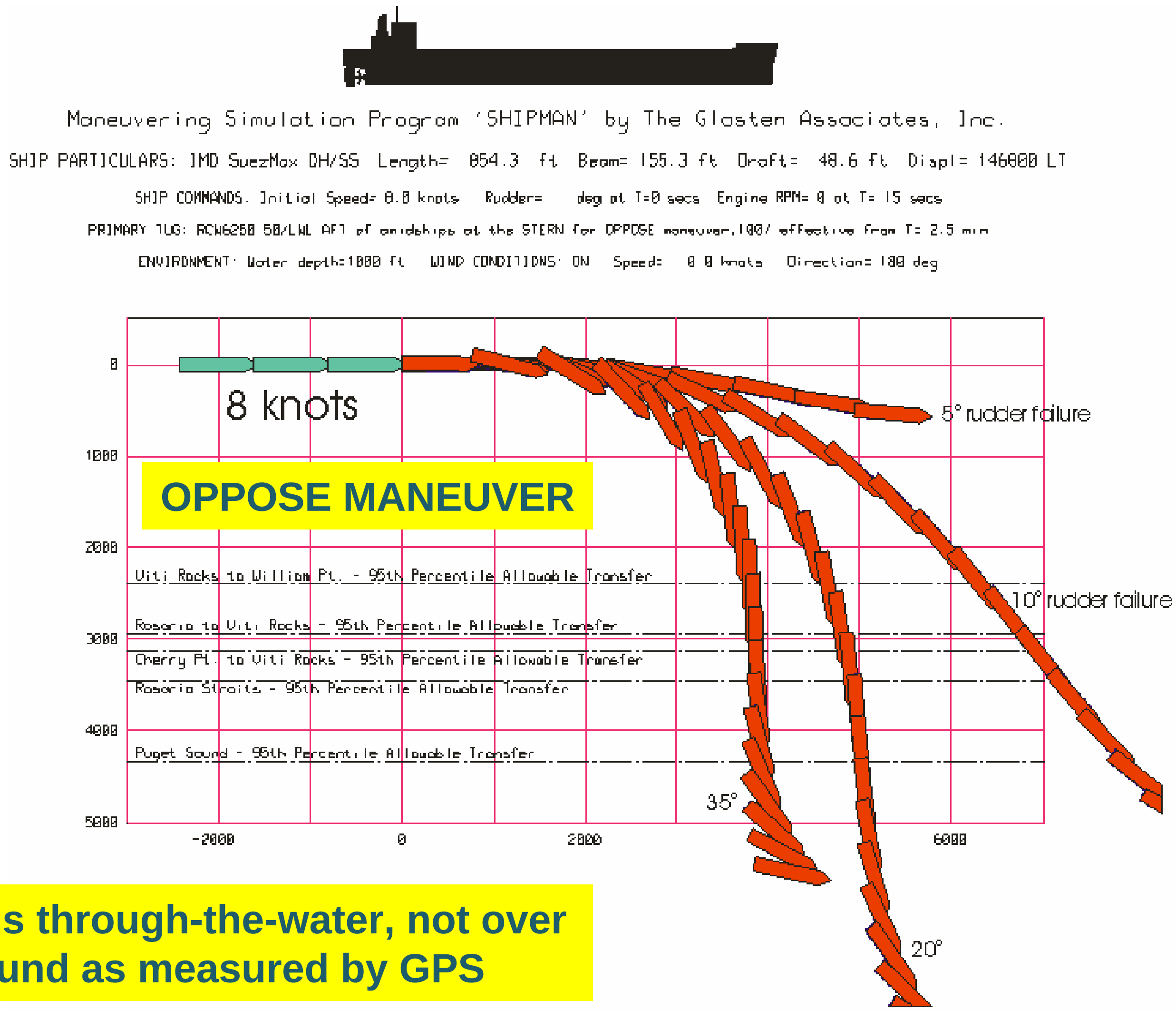
Channel Width Statistics – Rosario Straits



Channel Width Statistics – Rosario Straits

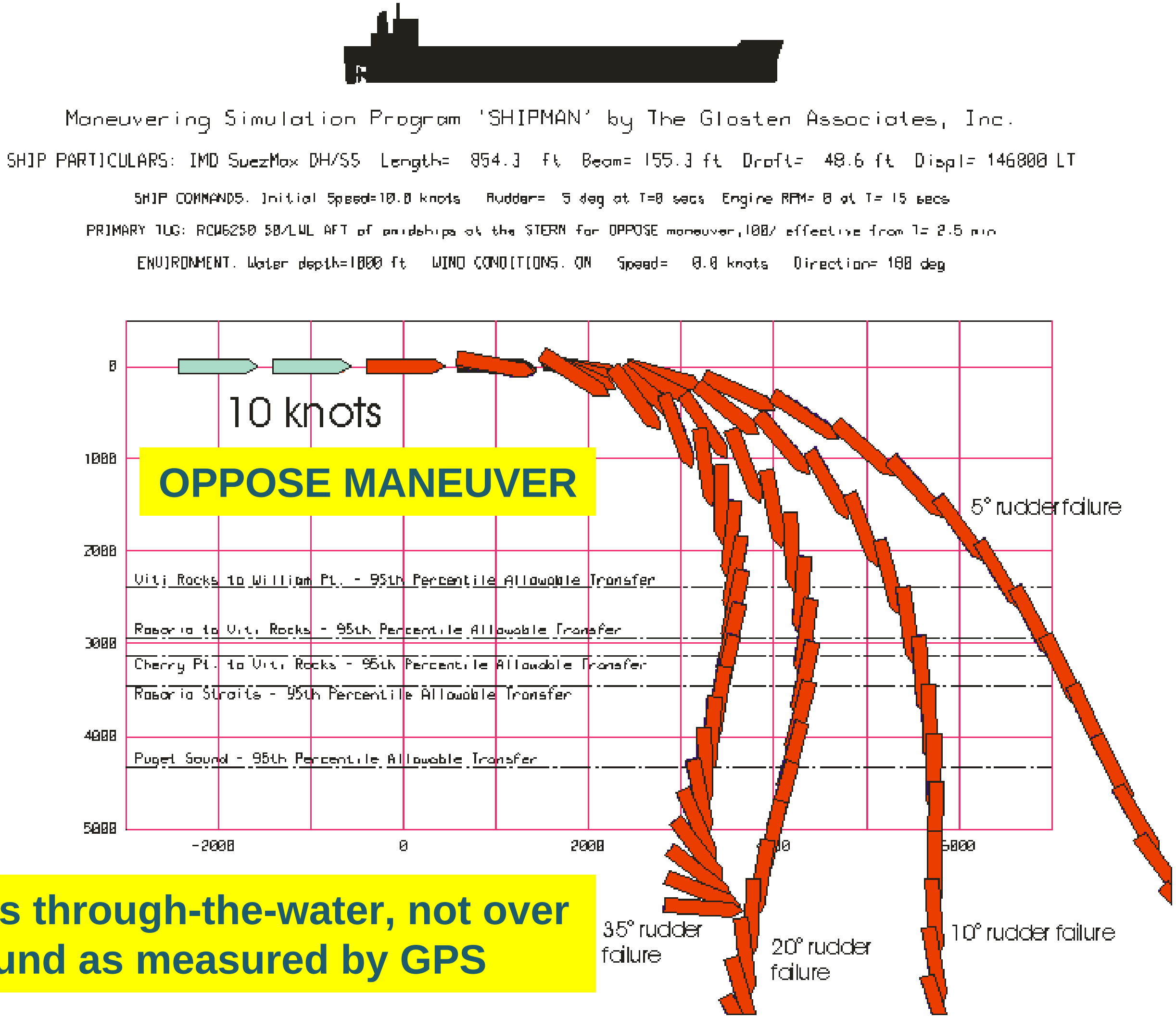


RCW Minimum Compliance Tug – Oppose Maneuver – SS Suez Max. Tanker



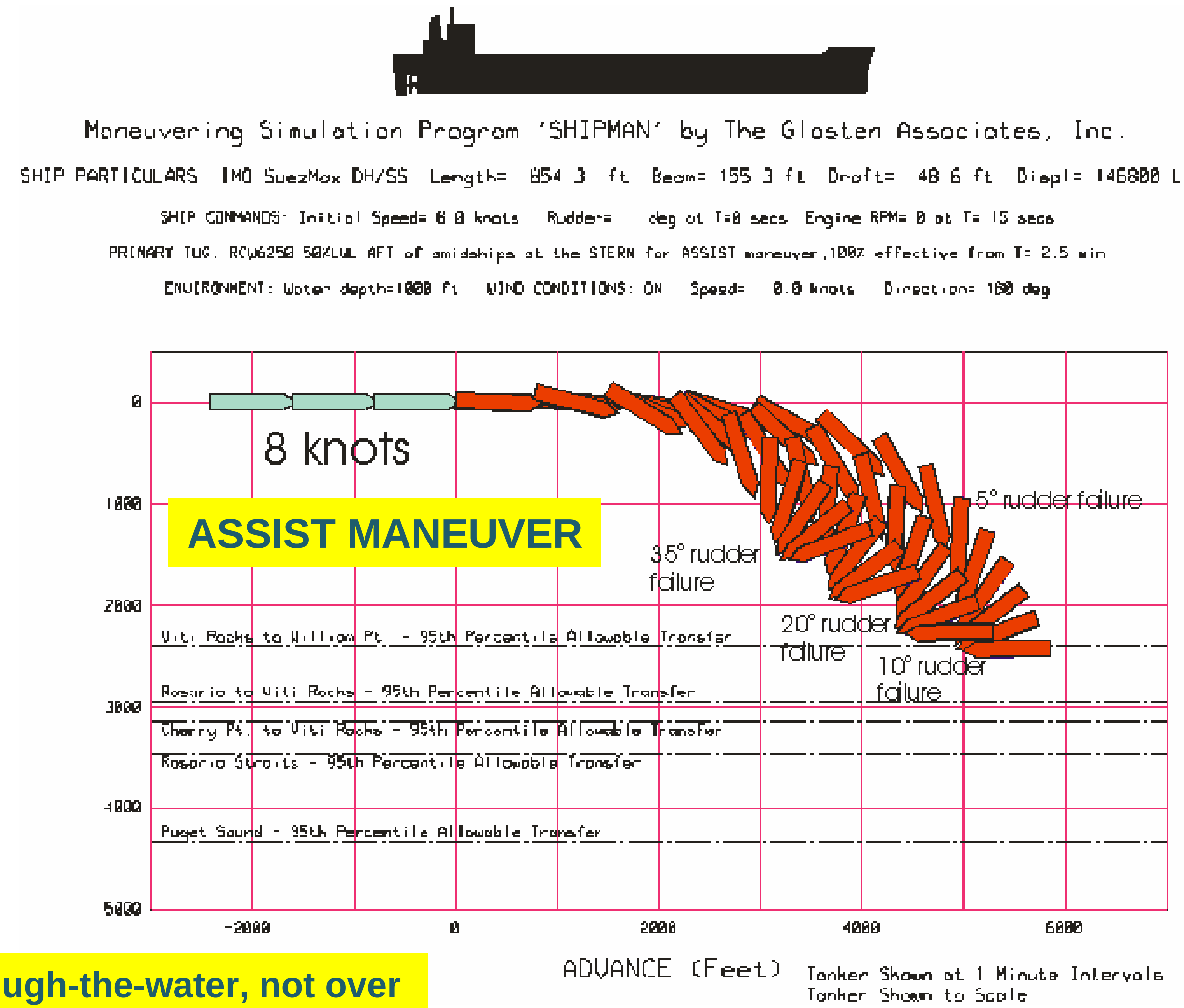
Speed is through-the-water, not over the ground as measured by GPS

RCW Minimum Compliance Tug – Oppose Maneuver – SS Suez Max. Tanker



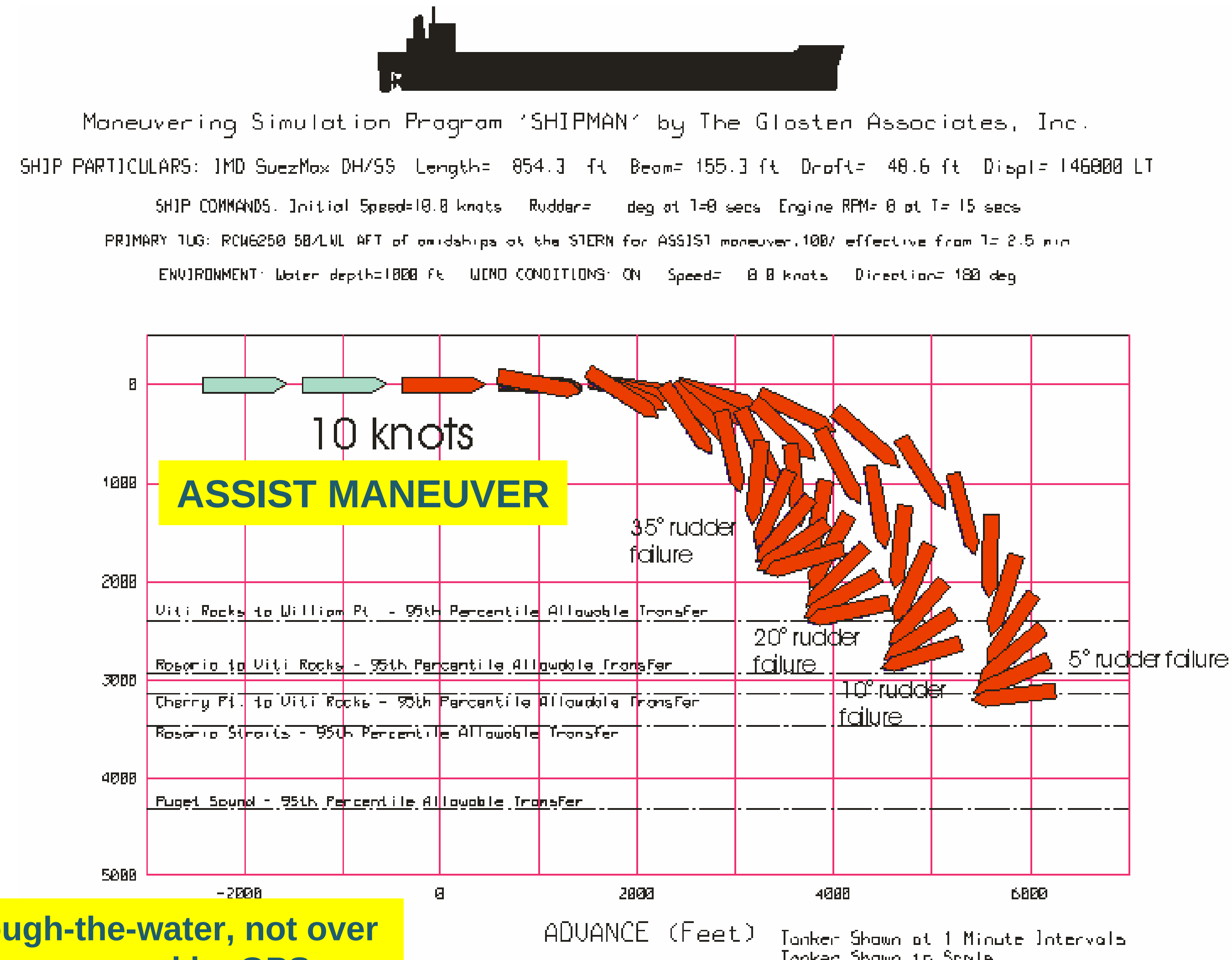
Speed is through-the-water, not over the ground as measured by GPS

RCW Minimum Compliance Tug – Assist Maneuver – SS Suez Max. Tanker



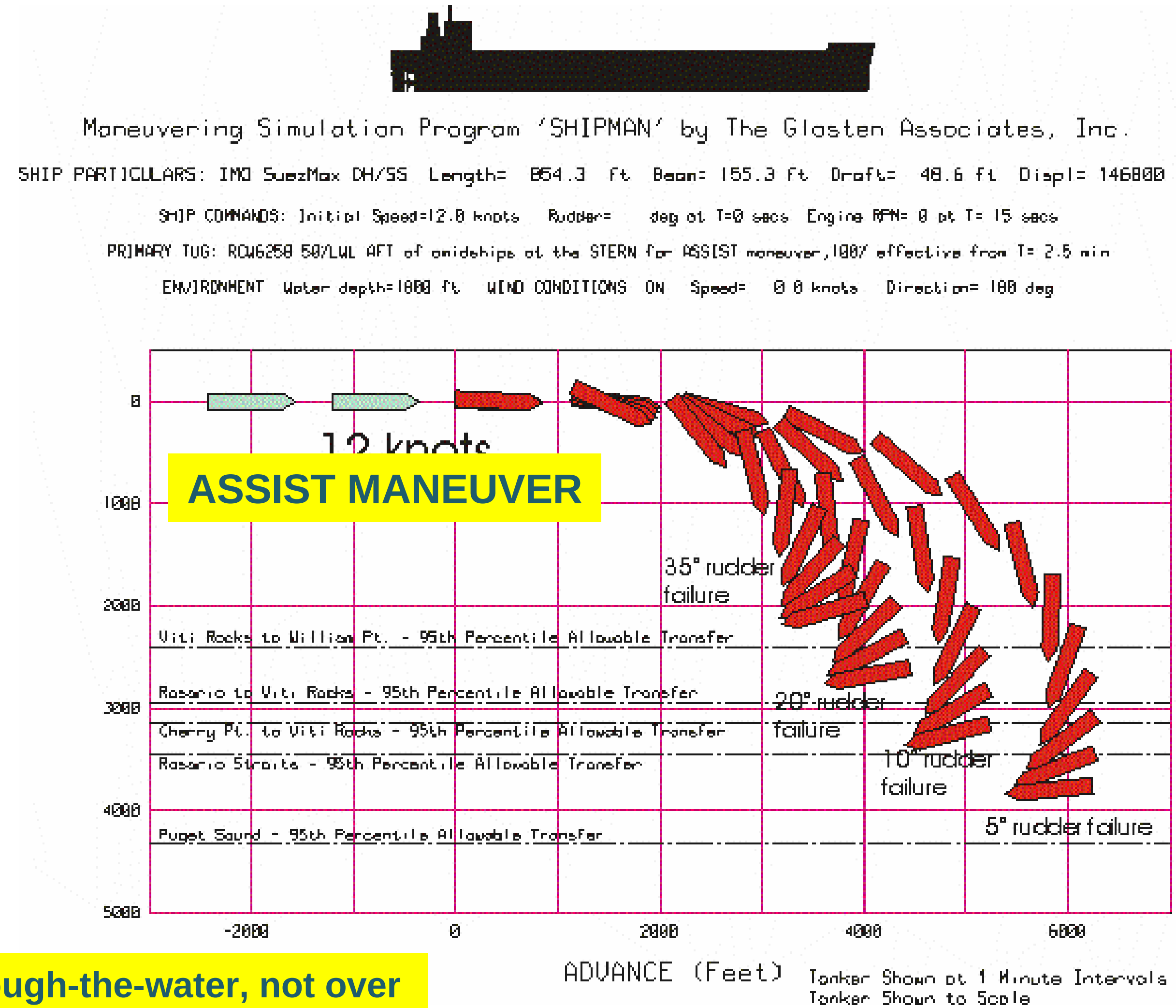
Speed is through-the-water, not over the ground as measured by GPS

RCW Minimum Compliance Tug – Assist Maneuver – SS Suez Max. Tanker



Speed is through-the-water, not over the ground as measured by GPS

RCW Minimum Compliance Tug – Assist Maneuver – SS Suez Max. Tanker



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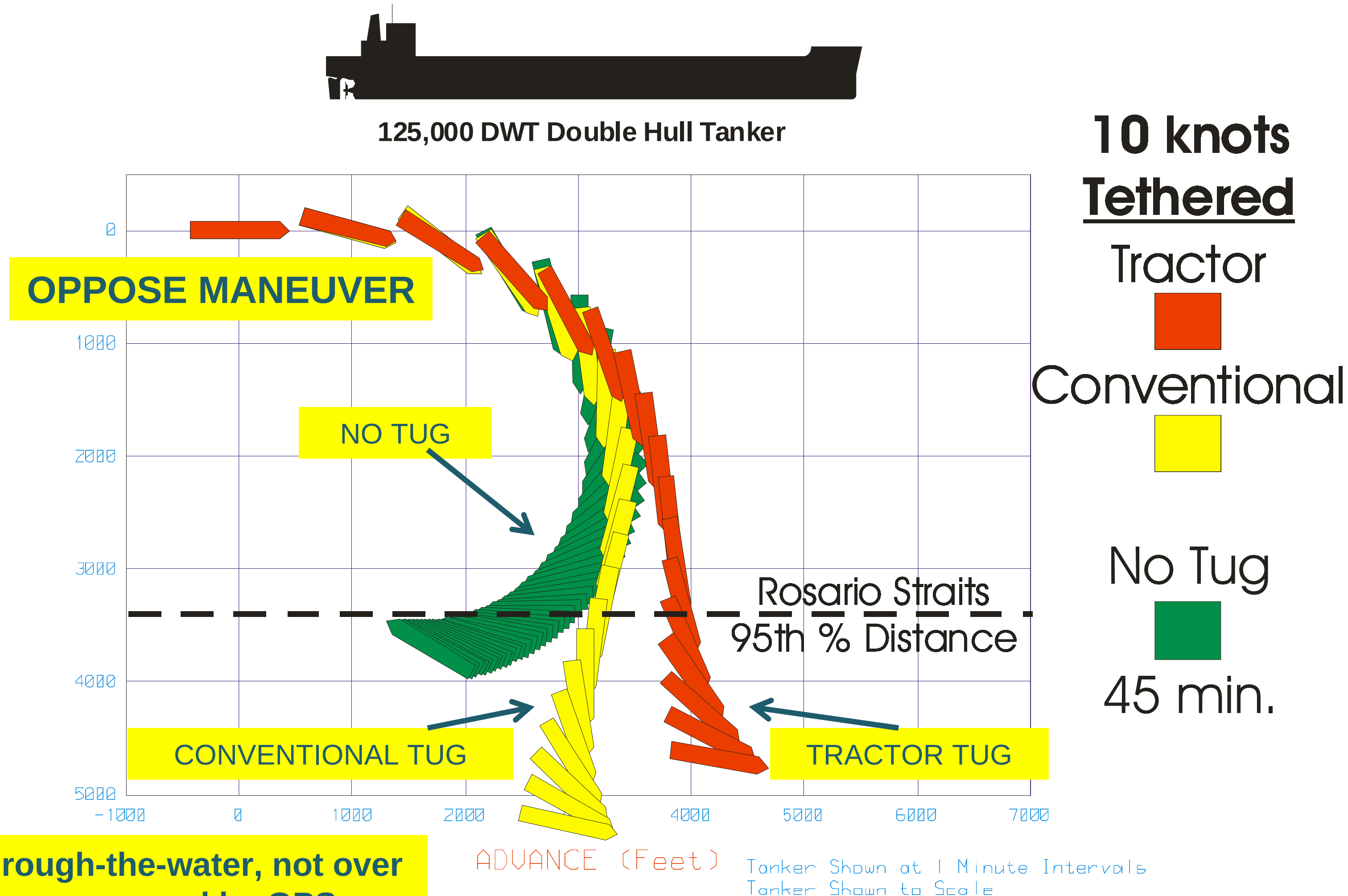
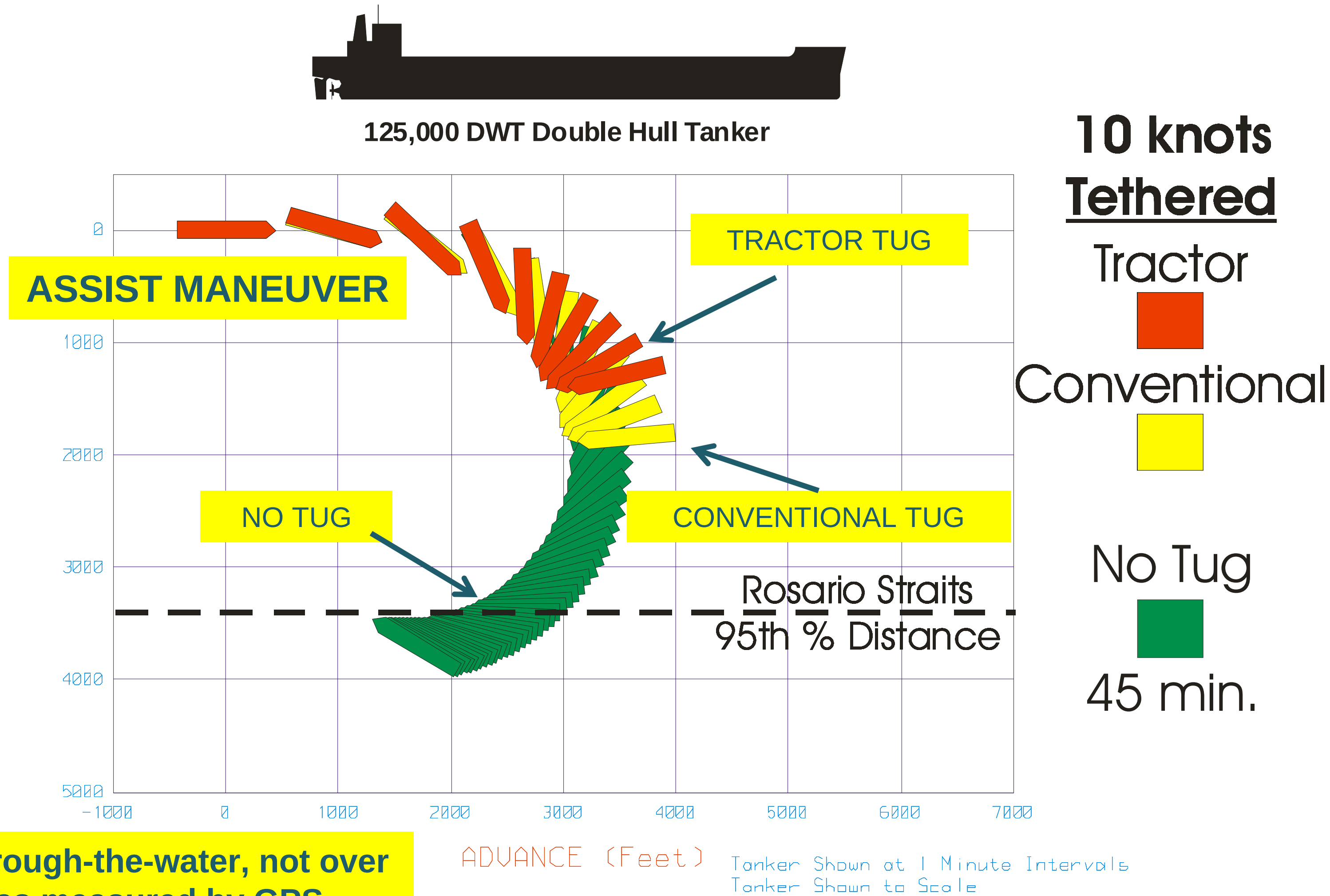
RCW Minimum Compliance Tug – Oppose Maneuver – SS Suez Max. Tanker



Speed is through-the-water, not over the ground as measured by GPS

RCW Minimum Compliance Tug – Assist Maneuver – SS Suez Max. Tanker



Speed is through-the-water, not over the ground as measured by GPS

Escort with RCW Minimum Compliance Tug – Single Screw Tanker

Tanker Escort with RCW Minimum Compliance Tug & a Single Screw Tanker can be Successful in Preventing a Grounding

Examples:

- 5º Rudder Failure at 8 kts in Rosario Straits – Oppose Maneuver is Successful
- 5º Rudder Failure at 10 or 12 kts in Rosario Straits – Oppose Maneuver is NOT Successful
- 10º Rudder Failure at 8 kts in Rosario Straits – Oppose Maneuver is Successful
- 5º – 35º Rudder Failure at 8 kts in Rosario Straits – Assist Maneuver is Successful
- 5º Rudder Failure at 10 kts in Rosario Straits – Assist Maneuver is NOT Successful
- 10º – 35º Rudder Failure at 10 in Rosario Straits – Assist Maneuver is Successful
- 5º & 10º Rudder Failures at 12 kts in Rosario Straits – Assist Maneuver is NOT Successful
- 15º - 35º Rudder Failures at 12 kts in Rosario Straits – Assist Maneuver is Successful

An Engineered Solution Exists that can Prevent a Grounding

However, Human Factors Govern the Probability of Success

Probability of Grounding – Redundant System Tankers

Engine Failure Frequency = ~ 5 in 10,000 (based on Puget Sound VTS Incident Reports)

Rudder Failure Frequency = ~ 4 in 10,000 (based on Puget Sound VTS Incident Reports)

Two Engine Failure Frequency = ~ 25 in 100,000,000 (2.5×10^{-7})

Two Rudder Failure Frequency = ~ 16 in 100,000,000 (1.6×10^{-7})

One Rudder Failure & One Engine Failure Frequency = ~ 20 in 100,000,000

Rate is per Transit

Preliminary Conclusions:

- **One Engine Failure** (leaving 1 engine & 2 rudders) **– Grounding can be Averted**
- **One Rudder Failure** (leaving 2 engines & 1 rudder) **– Grounding can be Averted**
- **Two Rudder Failures** (leaving 2 engines) **– Grounding can NOT be Averted**
- **One Rudder & One Engine Failure – Grounding can be Averted**
- **Two Engine Failures** (leaving 2 rudders) **– Grounding can NOT be Averted**

Thus Probability of Grounding = ~ 2.5×10^{-7} + 1.6×10^{-7} = ~ 4.1×10^{-7}

Probability of Grounding – Single Screw Tankers

Engine Failure Frequency = ~ 5 in 10,000 (based on Puget Sound VTS Incident Reports)

Rudder Failure Frequency = ~ 4 in 10,000 (based on Puget Sound VTS Incident Reports)

Given the above IFs the Probability of Grounding = ~ Zero

- **Therefore, Single Screw Tankers with Escort are less likely to ground then Redundant System Tankers without Escort (0 is less then 4.1 x 10^{-7})**
- **However if Human Factor Errors are greater than 5 in 10,000 then Redundant System Tankers without Escort are less likely to ground than Single Screw Tankers with Escort**
- **The Human Factors are more complex for Single Screw Tankers with Escort then Redundant System Tankers without Escort**

Human factor risks will be further developed and discussed in subsequent presentations and reports.

IMO Oil Outflow Methodology

Hypothetical outflow of Oil (IMO MARPOL 73/78 Regulation 23) requires outflow calculations for side and bottom damage

Acknowledgment: Risk Does Exist

Assumption: Vessel has been involved in a casualty event, breeching at least one tank

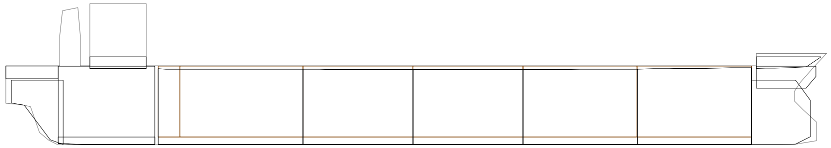
Methodology:

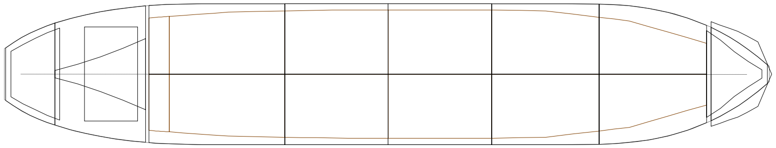
- Determine the probability of damage extent (once damage has occurred)
- Calculate the resulting consequences

This is accomplished by the following steps:

- Establish the Intact Load Condition
- Assemble Damage Cases
- Compute the Oil Outflow for Each Damage Case
- Compute the Oil Outflow Parameters
- Compute the Pollution Prevention Index "E"

The oil outflow calculation will be explained in more detail in subsequent presentations and reports.





Oil Outflow for Double Hull Tankers

Oil Outflow for Suez Max. Double Hull Single Screw Tankers

is approximately equal to

Oil Outflow for Suez Max. Double Hull Twin Screw Tankers

Oil Outflow for Partially Loaded Tankers is Greater than for Fully Laden Tankers (depending on loading configuration)

Oil Outflow for ATC and Polar tankers (with 3 meter double hull) loaded to 125,000 dwt will be Greater then Oil Outflow for IMO minimum compliance Suez Max. tanker (with 2 meter double hull) loaded to 125,000 dwt

These results will be check and verified by Herbert Engineering Corporation before publication in the final report.

Preliminary Conclusions

The Probability of Oil Outflow for Redundant System Double Hull Tankers without Escort

is less than

the Probability of Oil Outflow for Single Screw Double Hull Tankers with Escort

This preliminary conclusion is based on an assumption about human factor error rates and compensating measures that could be implemented for the auxiliary functions of an escort tug. These issues will be further evaluated and presented in subsequent presentations and reports.

Preliminary Conclusions

Revisions to the Washington State Tug Escort Regulations that should be considered:

- **Changing the requirement for tug escort for redundant system tankers (perhaps weather and/or waterway dependent)**
- **Define capability requirements for redundant system tankers (perhaps using ABS's notation R2S and / or R2S+)**
- **Add a performance requirement for tug - tanker escort taking into account tanker speed, weather, width of waterway and other factors, similar to OPA 90 part (a)**
- **Evaluate the consequence of dual loadlined tankers**
- **Compensating strategies for the loss of auxiliary escort tug functions (navigation, firefighting, first spill response)**

Other issues including the introduction of risk by escort tugs, the migration of risk and risk management factors will be evaluated and discussed in subsequent presentations and reports.

APPENDIX 5:
PUGET SOUND VTS INCIDENT SUMMARY

Between the years 1985 to 2003, there were six incidences of loss of steering by an oil tanker. These incidents are listed below with the notes recorded by the VTS operator at the time of the incident.

10/22/96	ARCADIA	Tanker Arcadia approaching Buoy RA was making a port turn crossing the bow of the southbound Tanker ARCO Fairbanks. PO Lankford tried calling Arcadia with no answer. Then called southbound ARCO Fairbanks to confirm that the Arcadia was in fact in a port turn. ARCO Fairbanks confirmed. PO Lankford tried calling the Arthur Foss, one of Arcadia's assist tugs. Arthur Foss indicated the Arcadia had experienced a steering casualty, the problem had been corrected and they were alongside and tied off to the tanker. Wind SSE / 20 kts
10/13/99	NEW ENDEAVOR	Inbound from Korea (laden tanker). Broken Rudder shaft. Being towed by SEASPAN COMMODORE to Port Angeles
10/29/99	BONN EXPRESS	Incident Type: Collision evasion Location: NW of Elliott Bay en route to Pier 18 in Seattle Weather: Overcast Bonn Express reported rudder stuck hard left; VTS directed USS Camden (and general broadcast) to take evasive action. Tugs alerted to possible response action. Bonn Express able to make repairs. Later reported that vessel shifted to different steering pump.
05/27/01	ITB GROTON	Casualty existing on inbound transit: Port rudder discovered missing when vessel anchored in PA on inbound transit to Cherry Point. Vessel laden 70,000 bbls of crude. P & S engines and stbd rudder are functional. COTP approved transit plan with two-tug escort to Cherry Point to offload, then to sea. Repairs to be accomplished in Dalian, China.
07/25/01	OS WASHINGTON	Pos (est) 48-31.0N, 124-58.3W: Vessel outbound in ballast seaward of Buoy J. Vessel in hand steering via trick wheel following completed loss of steering. Hydraulic telemotor failed on port steering system. Port motor shares a common drive with stbd motor. In operation, off-line motor is free-wheeling. When port motor locked up, it effectively disabled the other motor as well because it would not free-wheel when switched to stbd steering motor (design deficiency). After engineers removed the port motor from the system, the stbd motor was able to operate

		properly.
07/25/01	OS WASHINGTON	Overseas Washington reported a steering casualty and that they are steering from secondary station. Tanker slowed in speed to effect repairs. Lindsey Foss ordered to scene to assist. COTP ordered vessel into Port Angeles to effect repairs.

Between the years of 1985 to 2003, there were twelve incidences of loss of propulsion by an oil tanker. These incidents are listed below with the notes recorded by the VTS operator at the time of the incident.

04/29/89	EXXON PHILADELPHIA	Power loss. Weather not noted. Tanker EXXON PHILADELPHIA requested assistance at 48degrees 28' North, 124degrees 55' West (301T 9.1 mile from Cape Flattery). Tanker was experiencing mechanical difficulties.
01/22/92	SEALIFT CHINA SEA	Location: Off "CA" buoy Weather: current at slack Vessel reported starboard air line broke, common line broke, lost all air to engine room. Andrew Foss called for assistance; vessel subsequently made repairs and continued underway.
10/03/92	KAPITAN SPIVAK	Tanker Kapitan Spivak called and informed that the ship has lost engine power. Tug Andrew Foss, his assist tug, took the tanker in tow in Guemes Channel off Buoy #5 which helped keep the tanker in the channel. Tug Hunter assisted with bringing the tanker to anchor at Buoy R
06/27/94	SANT AMBROGIO	#10 cylinder on port main engine experienced an exhaust valve failure which caused damage to the liner, head, and piston. The vessel entered Puget Sound with only one main diesel engine operational.
08/16/96	STAVANGER OAK	Inbound Norwegian Tanker Stavanger Oak (DWT 37,350) had lost the use of one of their two main engines. The vessel was at that time about five miles NW of Cape Flattery. They were not asking for assistance and said this loss did not impair their maneuverability. Vessel's speed dropped from 13 kts to 4 kts to 2 kts. Vsl reported they hade found the problem and it would be repaired. Area:: Cape Flattery

		wind: slight
10/13/99	ANGELO D'AMATO	Inbound tank ship stopped at the Port Angeles pilot station and picked up a pilot. It was unable to immediately restart its engine; the reason for this proved to be that the main starting air valve was stuck. Winds: West at 20 knots Seas: none Swells: None Weather type: clear
01/06/01	ARAL	Lat 48-30.8N, Long. 123-10.5W. Per USCG Sitrep: About 12:25 p.m. vessel, in ballast, bound for Vancouver experienced an engine failure when its turbocharger exploded. The vessel went adrift about one mile west of Lime Kiln Point, San Juan Island. Ship drifted south-southwest (195 degrees) into Canadian waters at 1.3 knots, unable to use its anchor in the deep waters of Haro Strait. A Foss tug located off Dungeness Spit was called to assist, arrived at 2:26 p.m. and got the ship under tow for Esquimalt at 2:43 p.m.
03/27/01	ALFIOS 1	ALFIOS 1 has experienced intermittent propulsion failures while in transit from Cherry Point, WA to Port Angeles, WA (vic Buoy "C"). COTP directed two-tug escort to proceed to Port Angeles, WA. Per agent (Sunrise Shipping), cause due to water in fuel taken on outside of Washington.
03/27/01	ALFIOS 1	Per Agent, Sunrise Shipping: Ship lost power intermittently due to water in fuel taken on outside of Washington (ship bunkered in WA as well). Location at Buoy "C", tug ARTHUR FOSS escorting. COTP approved transit to PANG with two tug escort. During transit, ALFIOS lost power again, taken under tow by ARTHUR FOSS.
04/30/01	JO BREVIK	Barbara Foss was dispatched from Neah Bay to standby the M/V Jo Brevik as the crew replaced a faulty fuel valve on the main engine. Chemical tank ship carrying a cargo of liquid caustic soda (industrial lye), outbound from the Strait of Juan de Fuca. Vessel reported a faulty fuel valve, continued on slow ahead until 'cleared the coast'. The tug was called because of the weather conditions. Winds on scene were SW 22-27 knots with a six-foot swell. Repairs took about two hours, were completed before BF arrived alongside. Callout was at 2145, turnaround at 0045 this morning, and arrival back at Neah Bay at 0305.,

02/11/02	BLUE RIDGE	Position: 48.13100N, 123.42260W Per COTP Order 02-13: Vessel (in ballast) fouled the propeller and shaft with heavy mooring line and chain when getting underway from Port Angeles, WA on February 10, 2002. Rendered the vessel without means of propulsion and has caused damage to the shaft and propeller. Plan have the vessel towed from Port Angeles to Vancouver, B.C. for repairs.
04/15/02	POLAR ENDEAVOUR	Position 48.54306N, 122.56611W (assigned): Ship was bound from Ferndale to Anacortes refinery. Test was being done on IG equipment. When 300 hp electric motor for IG brought on-line, electrical power was lost. Loss of power then shut down lube oil pumps and subsequently both main engines. Redundant/independent engine rooms had been electrically tied in anticipation of spreading the electrical load, making them dependent and causing loss of both mains. Reportedly took a minute to reset electrical system and bring engines back on line. Ship near Saddlebag Is. when loss occurred. Two tugs were escorting the ship at the time of the loss, with one tethered to the stern and the other running near the bow of the ship. Steering and control of the ship was never lost, as electrical power to the wheelhouse and steering system remained available throughout the incident from a backup generator. Bridge back-ups and emergency gear apparently all worked as designed.

APPENDIX 6:
SOCIOECONOMIC VALUES PROTECTED

Following is a copy of the report entitled "Socioeconomic and Environmental Assets Potentially Protected by Tug Escorts And Other Spill Prevention Measures In San Juan Islands/Rosario Straits Region, Puget Sound, Washington," prepared by Environmental Research Consulting for this inclusion in this study.

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CONSULTING

Socioeconomic and Environmental Assets Potentially Protected by Tug Escorts And Other Spill Prevention Measures In San Juan Islands/Rosario Straits Region, Puget Sound, Washington

(Section 4)

Draft II

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SOCIOECONOMIC ASSETS POTENTIALLY PROTECTED BY TUG ESCORTS AND OTHER SPILL PREVENTION MEASURES IN SAN JUAN ISLANDS/ROSARIO STRAITS REGION, PUGET SOUND, WASHINGTON

Overview of Oil Spill Socioeconomic Costs

An oil spill can have serious socioeconomic impacts on the affected region, local communities, residents, the state, and the federal government. These impacts include damages to real and personal property, loss of use of natural resources (parks and recreation areas), and loss of income and expenses (fishing, tourism, recreation, shipping and other commerce). As a major shipping port and tourist and recreation area, the Puget Sound is particularly vulnerable to socioeconomic impacts from oil spills. Reduction in tourism, commercial fishing, and blocking the shipping port could have widespread impacts. There can also be serious impacts on the Tribal Nations, particularly with respect to subsistence fishing.

In the case of an oil spill, the Oil Pollution Act of 1990 allows the federal government to collect from responsible parties socioeconomic costs including:

- Loss of natural resources (lost-use);
- Losses for destruction of real/personal property;
- Losses of subsistence use of natural resources;
- Net loss of taxes/fees/net profit due to injury, destruction/loss of real/personal property or natural resources;
- Loss of profits or earning capacity due to damage to real/personal property or natural resources (*e.g.*, fish); and
- Governmental costs for providing increased or additional public services during or after removal activities.

In addition to the costs that the federal and state government authorities can collect, there are also possible third-party damage suits that can ensue. Successful damage suits in past oil spill incidents have included payments for:

- Out-of-pocket costs relating to removal of oil or restoration of impacted property;
- Economic losses, including lost revenues and profits due to lost tourism or business opportunities;
- Cost of repair/replacement of physical property damaged by a spill (*e.g.*, fishing nets, docks);
- Loss of revenues from decreased fishing resource;
- Increased cost of fishing due to necessity of fishing in different locations;
- Damages to real property, including potential damage to market values of properties "stigmatized" by an oil spill;
- Possible replacement of natural resources irretrievably oiled by the creation of new natural resources;
- Losses by sport fishermen incurred as result of curtailment of fishing; and
- Subsistence losses to American Natives.

The socioeconomic costs are based on the real and perceived impacts, which are related to the degree of oiling, the oil type and persistence, the degree to which cleanup operations can remove all offshore and onshore and mitigate the oil impacts, and the timing of the impact.

Potential Socioeconomic Impacts in San Juan Islands/Rosario Straits

A previous study conducted by Environmental Research Consulting (Contract No. C040018) in conjunction with Applied Science Associates, Inc., investigated the potential costs and impacts of oil spills in a variety of locations throughout Washington State waters (including San Juan Islands/Rosario Straits, Strait of Juan de Fuca, Inner Straits (Port Angeles to south end of Lopez Island), Outer Coast (Duntz Rock near Cape Flattery), and Columbia River (mouth and Portland to Longview). The trajectory, behavior, and potential impacts of the spilled oil were modeled using Applied Science Associates, Inc.'s SIMAP software modeling.

Oil spills involving 65,000 barrels of crude (hypothetical tanker), 65,000 barrels of No. 2 diesel fuel (hypothetical tanker), and 25,000 barrels of No. 6 fuel oil (hypothetical tank barge) were modeled at different locations. Various modes of spill response were applied, including:

- No response (with the exception of protective booming at locations designated by relevant geographic response plans
- Three levels of mechanical containment and recovery
    - Federal-mandated response capability level
    - State proposed response capability level
    - Higher hypothetical response capability level
- In-situ burning in conjunction with state proposed mechanical response capability level
- Dispersant application with state-proposed mechanical response capability level

The three levels of mechanical response capability relevant to the San Juan Islands spill scenarios are shown in Table 1. The three levels of response capability include cumulative amounts of containment boom, mechanical recovery capability, and storage capacity that differ in amount and timing. The spill scenarios modeled all involved 65,000-barrel crude tanker spills.

TABLE 1: Mechanical Spill Response Capabilities: San Juan Islands Spill 65,000 bbl ANS Crude

Hr	FEDERAL (Nearshore)			PROPOSED STATE			3RD HYPOTHETICAL ALTERNATIVE		
	Boom (ft)	*Recovery (bpd)*[1]	*Storage (bpd)*	*Boom (ft)*	*Recovery (bpd)*	*Storage (bpd)*	*Boom (ft)*	*Recovery (bpd)*	*Storage (bpd)*
2	-	-	-	3,500	-	-	3,500	-	-
4	-	-	-	-	-	-	20,000	36,000	36,000
6	-	-	-	20,000	12,000	12,000	-	-	-
12	30,000	12,500	25,000	40,000	36,000	54,000	40,000	48,000	56,000
24	-	-	-	40,000+	48,000	96,000	40,000	60,000	180,000
36	30,000	25,000	50,000	-	-	-	-	-	-
48	-	-	-	40,000	60,000	120,000	40,000	72,000	216,000
60	30,000	50,000	100,000	-	-	-	-	-	-
72	-	-	-	40,000+	72,000	120,000+	-	-	-

[1]bpd = barrels per day

The San Juan Islands/Rosario Straits scenarios modeled are shown in Table 2.

For each response, 100 randomized variations on winds, currents, and tides, as well as randomized spill location along the specified shipping lanes were modeled. For detailed analysis, the 5th, 50th, and 95th percentile[1] model runs were selected based on the relative shoreline impact.

[1] The 5th percentile is the spill model run (combination of winds, current, and tide) at which 5% of the spill model runs have lower impacts and 95% have higher impacts. The 95th percentile is the spill model run corresponds to that run for which only 5% of runs have higher impacts.

Different shoreline types (*e.g.,* wetlands, mudflats, rocky, sandy, artificial) were weighted by "relative cleanup cost" factors, which are related to degree of environmental sensitivity, difficulty of cleanup operations, and sensitivity to disturbance during response operations. Response costs, socioeconomic impacts, and environmental (natural resource) damages were estimated for each of the scenarios (response types).

Table 2: SAN JUAN ISLANDS/ROSARIO STRAITS OIL SPILL SCENARIOS MODELED

Scenario No.[1]	**Location (Shipping Lane)**	**Spill Type**[2,3]	**Modeled Responses ●**							
			None[4]	**Mechanical**[5]			**Mechanical + Dispersant**[6]			**Mechanical + ISB**[7] **State**
				Fed	**State**	**3rd**	**Fed**	**State**	**3rd**	
SI-Crud-N	Rosario/Georgia Strait S Lopez Island to Cherry Pt.	65,000 bbl ANS crude	●	--	--	--	--	--	--	--
SI-Crud-R-Fed	Rosario/Georgia Strait S Lopez Island to Cherry Pt.	65,000 bbl ANS crude	--	●	--	--	--	--	--	--
SI-Crud-R-ST	Rosario/Georgia Strait S Lopez Island to Cherry Pt.	65,000 bbl ANS crude	--	--	●	--	--	--	--	--
SI-Crud-R-3	Rosario/Georgia Strait S Lopez Island to Cherry Pt.	65,000 bbl ANS crude	--	--	--	●	--	--	--	--
SI-Crud-C-Fed	Rosario Strait/S Lopez Island to Pt. Lawrence	65,000 bbl ANS crude	--	--	--	--	●	--	--	--
SI-Crud-C-ST	Rosario Strait/S Lopez Island to Pt. Lawrence	65,000 bbl ANS crude	--	--	--	--	--	●	--	--
SI-Crud-C-3	Rosario Strait/S Lopez Island to Pt. Lawrence	65,000 bbl ANS crude	--	--	--	--	--	--	●	--

[1] Scenario numbers based on: SI = San Juan Islands; crud = crude; response type (R = "removal" for mechanical recovery only or *in-situ* burning; C = chemical dispersant application); and response level (N = no response; Fed = federal response capabilities; ST = state response capabilities; and 3 = hypothetical 3rd alternative response capabilities). [2] bbl = barrels (equivalent to 42 gallons). [3] ANS crude = Alaska North Slope crude. [4] "No response" means no *on-water* recovery or dispersion attempted. Protective booming, shoreline cleanup, salvage, and spill management/monitoring conducted as required. [5] On-water mechanical response conducted using federal, state, or hypothetical 3rd alternative response capabilities. Protective booming, shoreline cleanup, salvage, disposal, and spill management/monitoring conducted as required. [6]Dispersant applications conducted where permitted by state guidelines with concurrent mechanical response using federal, state, or hypothetical 3rd alternative response capabilities. Protective booming, shoreline cleanup, salvage, disposal, and spill management/monitoring conducted as required. [7]ISB = *in situ* burning was not modeled for this location as there were no locations where its use would likely be approved due to proximity to shoreline and populated coastal areas.

Socioeconomic resources at risk for oil spill impacts that were considered in this study included:

- **Ports**
    - Disruption of port business by response operations and presence of oil slicks in vessel traffic lanes and port areas and bans or reduction in traffic.
        - Costs for vessel operating delays in-port and at-sea.
        - Delays in port business (interest on delayed port business income).
        - Lost wages for port employees.
    - Impacts on marinas
        - Damage to boats (oiling)
        - Lost income due to marina not being usable
- **Commercial Fishing**
    - Loss of income from shellfishing
    - Loss of shellfish (wholesale costs)

- Loss of income from fishing
    - Loss of fish (wholesale costs)
    - Damage to fishing equipment and boats
- **Tribal Nations**
    - Impacts on Tribal lands
    - Fishing income losses
    - Subsistence Fishing
- **Parks and Recreation**
    - National and state parks
        - Lost income from national and state parks
        - Lost use of national and state parks
    - Recreational boating
        - Lost income from state parks
        - Lost use of state parks
    - Sportfishing
        - Lost income from sportfishing
        - Loss of sporting fish
        - Lost use of sportfishing
    - Wildlife viewing and nature study
        - Lost income
        - Lost use
        - Wildlife hunting
- **Tourism**
    - Lost direct income from tourism
    - Lost indirect income from tourism

Impacts on Ports

The impact that modeled Washington oil spills and response operations would have on port areas in Washington and British Columbia (shown in Figures 1 and 2), were examined. Port areas were assumed to be impacted when floating oil was 10 g/m^2 or higher.

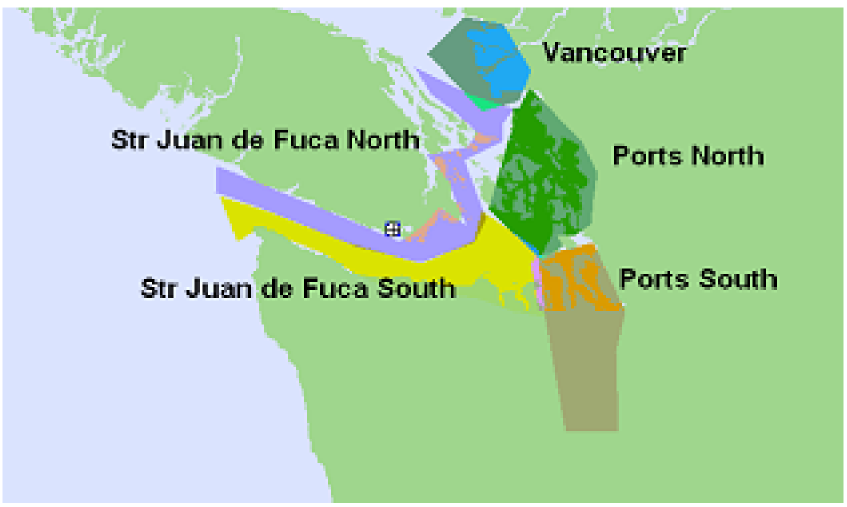

Figure 1: Port areas used in modeling of Washington spill scenarios

Disruption of port business by response operations and presence of oil slicks in vessel traffic lanes and port areas and bans or reduction in traffic was considered from the perspective of vessel operating costs, delays in port business, and lost wages for port employees (labor).

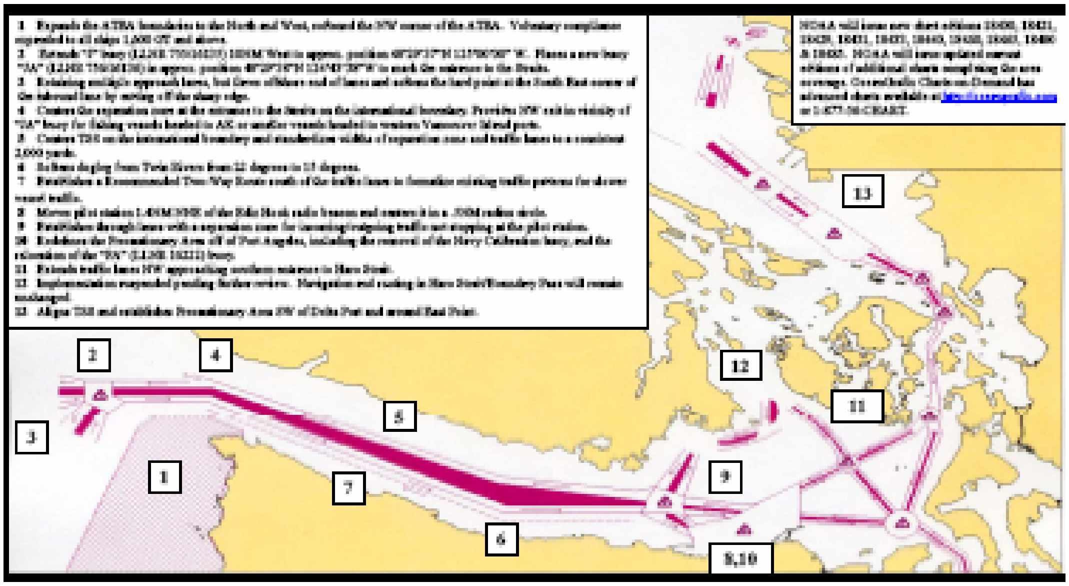

Figure 2: Traffic Separation Scheme in Puget Sound (Source: Puget Sound Vessel Traffic Service)

Costs for Operating Delayed Vessels In-Port and At-Sea

The typical annual vessel traffic for the Puget Sound was determined (as shown in Table 3). Vessel operation costs for vessels idling at sea (unable to enter the port area) and operation costs for vessels delayed in the port (unable to leave) were based on US Army Corps of Engineers (2000*a,b*) costs for operation of vessels. It was assumed that 50% of the vessels would be at sea (or entering the port areas) and 50% would be in the ports (or attempting to leave the port areas) at any one time. The annual vessel traffic was assumed to be distributed evenly across the year to determine daily port visits. The distribution of vessel types on any one day was assumed to be the same as across the entire year. The costs for operating at-sea and in-port were averaged and multiplied by daily vessel visits per port.

Ports were assumed to be blocked only to the extent that the oil covered the port area (and port entry areas in the straits) and for the estimated duration of on-water response operations, during which time vessel traffic would be curbed. In Puget Sound, the blockage was assumed to be six days for crude and bunker spills (with the crude oil dissipating more rapidly than the bunker fuel, but also containing 65,000 bbl of oil rather than 25,000 bbl as for the bunker fuel spills). The diesel spills were assumed to cause two days of blockage due to the higher rate of dissipation and evaporation of this oil type. In all cases, the blockage area was assumed to be three times the actual area of oil covered, again to allow for response operations and for the diversion of a larger number of vessels.Blockages to the Strait of Juan de Fuca were assumed to affect all Puget Sound ports. Blockages to inner areas of the sound were assumed to impact vessel traffic going both in and out of the inner ports.

Table 3: Oiling of Port Areas and Access: San Juan Islands 65,000-bbl Crude Spill						
Response	**% Surface Area Covered by Floating Oil > 10g/m^2**					
	5th	**50th**	**95th**	**Mean**	**Mean+2SD**	**Mean-2SD**
No Response	4.04%	2.26%	1.87%	2.73%	5.04%	0.41%
Mechanical-Federal	0.46%	0.34%	0.74%	0.51%	0.93%	0.10%
Mechanical-State	0.28%	0.30%	0.64%	0.41%	0.81%	0.00%
Mechanical-3rd	0.20%	0.29%	0.52%	0.34%	0.67%	0.00%
Dispersant-Federal	0.19%	0.30%	0.53%	0.34%	0.68%	0.00%
Dispersant-State	0.23%	0.33%	0.62%	0.40%	0.80%	0.00%
Dispersant-3rd	0.19%	0.30%	0.53%	0.34%	0.68%	0.00%
[1]Puget Sound and Straits ports only.						

Delays in Port Business

Delays in port business were assumed to be directly related to the vessel blockage. The costs were estimated based on annual reported vessel-related business in the ports (based on information from the port websites and personal communications with the port operators). Business was assumed to be delayed rather than completely voided. In other words, the business would still be conducted, but at a delayed time. The delay cost was based on 7% annual interest (0.019% daily interest for each day of delay). Lost wages for port employees (paid hourly wages) were based on the number of days of blocked port business (again based on vessel blockage and oiled areas) and the daily wages for each port (Tables 4 – 11).

At the same time, delays in port business were assumed to *save* the port operators the majority of their operating costs during the time period of the port blockage, again to the extent that the ports were blocked. The costs to labor and the costs to the port operators represent different types of costs and need to be counterbalanced in cost-benefit analyses (Table 11).

Table 4: Cost Impact of Oiling of Port Areas and Access in Oil Spill Scenarios

Response	Vessel Delay Operating Costs					
	5th	50th	95th	Mean	Mean+2SD	Mean-2SD
No Response	$183,395	$102,673	$84,916	$123,661	$228,635	$18,687
Mechanical-Federal	$20,991	$15,415	$33,668	$23,358	$42,066	$4,650
Mechanical-State	$12,849	$13,407	$28,962	$18,406	$36,698	$114
Mechanical-3rd	$9,111	$13,058	$23,666	$15,278	$30,332	$224
Dispersant-Federal	$8,685	$13,446	$23,945	$15,359	$30,718	$0
Dispersant-State	$10,569	$15,059	$28,148	$17,925	$35,850	$0
Dispersant-3rd	$8,685	$13,446	$23,945	$15,359	$30,718	$0

[1]Vessel blockage of entry or departure from ports is assumed to be 6 days for the Columbia River for bunker spills with % block five times percentage of area covered (due to narrowness of river). Vessel blockage in Puget Sound is assumed to be 6 days for crude and bunker spills and 2 days for diesel spills with blockage % three times that of area covered by oil (due to high traffic).

Table 5: Daily Impact of Port Disruption Due to Oil Spill and Response Operations

Port	Wages	Operating	Business	Delay Business[2]
Anacortes	$1,849	N/A	$29,103	$5.53
Bellingham	$348	$25,690	$2,507	$0.48
Everett	$2,778	$35,928	$10,567	$2.01
Olympia	$3,625	$3,625	$978,811	$18.60[3]
Port Angeles	$586	$16,389	$24,351	$4.63
Port Gamble	$82	N/A	$2,203[1]	$0.42[1]
Seattle	$179,517	$595,616	$4,328,767	$822.47
Tacoma	$211,713	$186,849	$1,290,411	$245.18
Vancouver	$1,026,733	N/A	$75,000,000	$14,250.00

Sources: Port budgets and port websites. [1]Extrapolated from daily wages and estimated size of port. [2]Based on daily interest rate of 0.019% (annual rate 7%).

Table 6: Vessel and Oil Movements Through Puget Sound (2000)								
Vessel Type	**Vessel Size**	**Transits Per Year**	**Daily # Vessels**	**Daily Cost Sea/Vessel**	**Daily Cost at Sea**	**Daily Cost in Port/Vessel**	**Daily Cost in Port**	**Average Daily Cost (Port +Sea/2)**
Crude tankers (laden)	<75,000 DWT	79	0.22	$21,000	$4,545	$18,000	$3,896	$4,221
	75,000-110,000 DWT	81	0.22	$27,000	$5,992	$23,000	$5,104	$5,548
	>110,000 DWT	138	0.38	$30,000	$11,342	$25,000	$9,452	$10,397
Crude tankers (ballast)	avg. 67,000 DWT	6	0.02	$25,000	$411	$20,000	$329	$370
Product tankers (laden)	avg. 22,000 DWT	12	0.03	$17,000	$559	$14,000	$460	$510
	avg. 55,000 DWT	23	0.06	$20,000	$1,260	$17,000	$1,071	$1,166
Product tankers (ballast)	avg. 22,000 DWT	20	0.05	$17,000	$932	$14,000	$767	$849
	avg. 55,000 DWT	179	0.49	$20,000	$9,808	$17,000	$8,337	$9,073
Product barges (laden)	avg. 6,000 DWT	5	0.01	$15,000	$205	$10,000	$137	$171
	avg. 12,000 DWT	18	0.05	$16,000	$789	$11,000	$542	$666
Bulk carriers	<50,000 DWT	1,913	5.24	$15,000	$78,616	$12,000	$62,893	$70,755
	50,000-100,000 DWT	501	1.37	$17,000	$23,334	$13,000	$17,844	$20,589
	>100,000 DWT	122	0.33	$20,000	$6,685	$14,000	$4,679	$5,682
Bulk liquid carriers		186	0.51	$17,000	$8,663	$14,000	$7,134	$7,899
Containerships	<2,500 TEU	435	1.19	$19,000	$22,644	$15,000	$17,877	$20,260
	2,500-4,000 TEU	510	1.40	$29,000	$40,521	$21,000	$29,342	$34,932
	>4,000 TEU	394	1.08	$50,000	$53,973	$30,000	$32,384	$43,178
Vehicle carriers		316	0.87	$15,000	$12,986	$11,000	$9,523	$11,255
Factory fishing vessels	300-3,000 GRT	59	0.16	$5,000	$808	$3,000	$485	$647
	>3,000 GRT	112	0.31	$11,000	$3,375	$6,000	$1,841	$2,608
Fishing boats	>300 GRT	167	0.46	$2,000	$915	$1,000	$458	$686
Passenger vessels	300-3000 GRT	16	0.04	$3,000	$132	$2,000	$88	$110
	>3,000 GRT	11	0.03	$5,000	$151	$3,000	$90	$121
TOTALS				**$416,000**	**$288,647**	**$314,000**	**$214,734**	**$251,690**
Adapted from Herbert Engineering, *et al*. 1999								

Table 7: Ports Disruption Due to Oil Spill and Response Operations By Port Area Impact				
Port	Modeled Impacted Port Area(s)		Total Daily Impact[2]	
	Incoming Traffic	Outgoing Traffic	Labor	Port
Anacortes	Str. Juan de Fuca South Ports North	Str. Juan de Fuca South Str. Juan de Fuca North[1] Ports North	**$1,849**	**($1,843)**
Bellingham	Str. Juan de Fuca South Ports North	Str. Juan de Fuca South Str. Juan de Fuca North[1] Ports North	**$348**	**($25,690)**
Everett	Str. Juan de Fuca South Ports North	Str. Juan de Fuca South Str. Juan de Fuca North[1] Ports North	**$2,778**	**($35,926)**
Olympia	Str. Juan de Fuca South Ports South	Str. Juan de Fuca South Str. Juan de Fuca North[1] Ports South	**$3,625[3]**	**($3,606)[3]**
Port Angeles	Str. Juan de Fuca South	Str. Juan de Fuca North[1]	**$586**	**($16,384)**
Port Gamble	Str. Juan de Fuca South Ports South	Str. Juan de Fuca South Str. Juan de Fuca North[1] Ports South	**$82[3]**	**($82)[3]**
Seattle	Str. Juan de Fuca South Ports South	Str. Juan de Fuca South Str. Juan de Fuca North[1] Ports South	**$179,517**	**($594,794)**
Tacoma	Str. Juan de Fuca South Ports South	Str. Juan de Fuca South Str. Juan de Fuca North[1] Ports South	**$211,713**	**($186,604)**
Vancouver	Str. Juan de Fuca North[1] Vancouver	Str. Juan de Fuca North[1] Vancouver	**$1,026,733**	**($1,012,483)**

Sources: Port budgets and port websites. [1]Includes Haro Strait as per map in Figure 6. [2]Assumes savings of operating expenses (including wages) and 0.019% daily interest on delayed business. Wages are loss to labor, but savings for port business. . [3]Extrapolated from daily wages and estimated size of port.

Table 8: Annual Export and Import Pass-Through for Washington's Ports					
EXPORTS ($ million)			IMPORTS ($ million)		
Commodity	Annual Pass-Through	Daily Interest Loss	Commodity	Annual Pass-Through	Daily Interest Loss
Aircraft	$26,257	$4.99	**Aircraft Engines**	$2,816	$0.54
Forest Products	$2,769	$0.53	**Forest Products**	$4,536	$0.86
High Tech	$2,686	$0.51	**High-Tech**	$10,428	$1.98
Data Processing Machines	$1,068	$0.20	**Data Processing Machines**	$1,855	$0.35
Aircraft Parts	$1,024	$0.20	**Aircraft Parts**	$2,123	$0.41
Corn	$908	$0.18	**Petroleum Gas**	$2,421	$0.46
Wheat	$758	$0.14	**Arcade Game Parts**	$1,918	$0.36
Seafood	$635	$0.12	**Toys**	$1,229	$0.23
Motor Vehicle Parts	$605	$0.11	**Motor Vehicle Parts**	$2,473	$0.47
Typewriter/Office Parts	$454	$0.09	**Motor Vehicles**	$3,740	$0.72
TOTAL	**$51,164**	**$9.72**	**TOTAL**	**$65,677**	**$12.47**
TOTAL DAILY BUSINESS INTEREST LOSS FOR DELAY IN BUSINESS = $22.19 million					

Source: Washington Public Ports Association (1999 data adjusted to 2003 $). [1]Based on daily interest rate of 0.019% (annual rate 7%) for delay in business.

Table 9: Cost Impact of Oiling of Port Areas and Access in Oil Spill Scenarios						
Response	**Disruption of Port Business (Business Interest Due to Delay)**					
	5th	**50th**	**95th**	**Mean**	**Mean+2SD**	**Mean-2SD**
No Response	$3,728	$2,086	$1,726	$2,519	$4,651	$378
Mechanical-Federal	$424	$314	$683	$471	$858	$92
Mechanical-State	$258	$277	$591	$378	$747	$0
Mechanical-3rd	$185	$268	$480	$314	$618	$0
Dispersant-Federal	$175	$277	$489	$314	$628	$0
Dispersant-State	$212	$305	$572	$369	$738	$0
Dispersant-3rd	$175	$277	$489	$314	$628	$0
[1]Vessel blockage in Puget Sound is assumed to be 6 days for crude and bunker spills and 2 days for diesel spills with blockage % three times that of area covered by oil (due to high traffic).						

Table 10: Cost Impact of Oiling of Port Areas and Access in Oil Spill Scenarios						
Response	**Lost Wages Due to Port Business Disruption**					
	5th	**50th**	**95th**	**Mean**	**Mean+2SD**	**Mean-2SD**
No Response	$1,189,428	$665,373	$550,552	$133,958	$247,307	$120,709
Mechanical-Federal	$135,430	$100,100	$217,866	$25,025	$45,634	$29,441
Mechanical-State	$82,436	$88,324	$188,424	$20,118	$39,746	$0
Mechanical-3rd	$58,883	$85,380	$153,095	$16,683	$32,876	$0
Dispersant-Federal	$55,938	$88,324	$156,039	$16,683	$33,367	$0
Dispersant-State	$67,715	$97,156	$182,536	$19,628	$39,255	$0
Dispersant-3rd	$55,938	$88,324	$156,039	$16,683	$33,367	$0
[1]Vessel blockage in Puget Sound is assumed to be 6 days for crude and bunker spills and 2 days for diesel spills with blockage % three times that of area covered by oil (due to high traffic).						

Table 11: Cost Impact of Oiling of Port Areas and Access in Oil Spill Scenarios						
Response	**Savings to Port Due to Port Business Disruption**					
	5th	**50th**	**95th**	**Mean**	**Mean+2SD**	**Mean-2SD**
No Response	$455,085	$254,577	$210,646	$307,520	$567,729	$46,184
Mechanical-Federal	$51,817	$38,299	$83,357	$57,449	$104,760	$11,264
Mechanical-State	$31,541	$33,793	$72,093	$46,184	$91,242	$0
Mechanical-3rd	$22,529	$32,667	$58,575	$38,299	$75,472	$0
Dispersant-Federal	$21,402	$33,793	$59,702	$38,299	$76,598	$0
Dispersant-State	$25,908	$37,173	$69,840	$45,058	$90,116	$0
Dispersant-3rd	$21,402	$33,793	$59,702	$38,299	$76,598	$0
[1]Vessel blockage in Puget Sound is assumed to be 6 days for crude and bunker spills and 2 days for diesel spills with blockage % three times that of area covered by oil (due to high traffic).						

Marinas

Impacts to marinas included the cost of daily lost income from actual marina data on moorage fees and other income per berth in the marina (as presented on marina websites) for the time that the marina would be unusable or severely compromised, and the cost of having to clean boats and berths on a per-boat, or per-berth basis. The cleaning costs for boats were based on personal communications with marina operators and commercial marine businesses. The costs for cleaning were adjusted to take into account the persistence of the oil, visibility, and ease of cleanup based on oil type. The costs for diesel cleanups were $200 per boat, $500 per boat for heavy fuel oil (bunker), and $300 per boat for crude oil. (Table 12) Results are shown in Tables 13 and 14.

Table 12: Marinas Potentially Impacted by Oil Spill Scenarios

Modeling Location	Marinas	Total Berths	Daily Lost Income[1]	Damage to Boats and Marina Property[2]		
				Diesel	Bunker	Crude
Portland	Parkers Landing	356	$7,120	$71,200	$178,000	$106,800
	Port of Ilwaco	800	$16,000	$160,000	$400,000	$240,000
	TOTAL	**1,156**	**$23,120**	**$231,200**	**$578,000**	**$346,800**
Ports North	Blaine Harbor	600	$12,000	$120,000	$300,000	$180,000
	Friday Harbor Marina	500	$10,000	$100,000	$250,000	$150,000
	LaConner Marina	460	$9,200	$92,000	$230,000	$138,000
	Lopez Islander Resort	160	$3,200	$32,000	$80,000	$48,000
	Oak Harbor Marina	420	$8,400	$84,000	$210,000	$126,000
	Port of Edmonds	676	$13,520	$135,200	$338,000	$202,800
	Shishole Marina	1,500	$30,000	$300,000	$750,000	$450,000
	Squalicum Harbor	1,404	$28,080	$280,800	$702,000	$421,200
	TOTAL	**5,720**	**$114,400**	**$1,144,000**	**$2,860,000**	**$1,716,000**
Ports South	Bell Harbor Marina	70	$1,400	$14,000	$35,000	$21,000
	Bremerton Marina	25	$500	$5,000	$12,500	$7,500
	City of DesMoines Marina	840	$16,800	$168,000	$420,000	$252,000
	Elliot Bay Marina	1,200	$24,000	$240,000	$600,000	$360,000
	Harbor Island Marina	80	$1,600	$16,000	$40,000	$24,000
	Point Hudson Marina	45	$900	$9,000	$22,500	$13,500
	Port of Brownsville Marina	415	$8,300	$83,000	$207,500	$124,500
	Port of Everett Marina	2,050	$41,000	$410,000	$1,025,000	$615,000
	Port of Kingston Marina	320	$6,400	$64,000	$160,000	$96,000
	Port of Poulsbo Marina	130	$2,600	$26,000	$65,000	$39,000
	Port Orchard Marina	130	$2,600	$26,000	$65,000	$39,000
	Port Townsend Haven	6,000	$120,000	$1,200,000	$3,000,000	$1,800,000
	Salmon Bay Marina	168	$3,360	$33,600	$84,000	$50,400
	Swantown Marina	700	$14,000	$140,000	$350,000	$210,000
	TOTAL	**12,173**	**$243,460**	**$2,434,600**	**$6,086,500**	**$3,651,900**
Str Juan de Fuca South	Port Angeles Marina	520	$10,400	$104,000	$260,000	$156,000
	TOTAL	**520**	**$10,400**	**$104,000**	**$260,000**	**$156,000**
Vancouver	Bayshore West Marina	400	$8,000	$80,000	$200,000	$120,000
	Coal Harbor Marina	238	$4,760	$47,600	$119,000	$71,400
	Pelican Bay Marina	600	$12,000	$120,000	$300,000	$180,000
	Royal Vancouver YC	500	$10,000	$100,000	$250,000	$150,000
	Shelter Island Marina	400	$8,000	$80,000	$200,000	$120,000
	Vancouver Marina	400	$8,000	$80,000	$200,000	$120,000
	TOTAL	**2,538**	**$50,760**	**$507,600**	**$1,269,000**	**$761,400**

[1]Based on extrapolated marina income from actual marina data (moorage fees and other income, estimated at $20). [2]Based on cost of boat cleanup as per personal communications with marina representatives and oil type factors (persistence, visibility, ease of removal) – $200/boat diesel; $500/boat heavy fuel oil, and $300/boat crude oil.

Table 13: Oiling of Marina Areas in Oil Spill Scenarios						
Response	% Area Covered by Oil (> 0.01 g/m^2)					
	5th	50th	95th	Mean	Mean+2SD	Mean-2SD
No Response	4.04%	2.26%	1.87%	2.73%	5.04%	0.41%
Mechanical-Federal	0.46%	0.34%	0.74%	0.51%	0.93%	0.10%
Mechanical-State	0.28%	0.30%	0.64%	0.41%	0.81%	0.00%
Mechanical-3rd	0.20%	0.29%	0.52%	0.34%	0.67%	0.00%
Dispersant-Federal	0.19%	0.30%	0.53%	0.34%	0.68%	0.00%
Dispersant-State	0.23%	0.33%	0.62%	0.40%	0.80%	0.00%
Dispersant-3rd	0.19%	0.30%	0.53%	0.34%	0.68%	0.00%

Table 14: Income Loss and Damages from Oiling of Marina Areas in Oil Spill Scenarios						
Response	Total Costs of Marina Oiling Impacts					
	5th	50th	95th	Mean	Mean+2SD	Mean-2SD
No Response	$324,985	$125,417	$103,588	$150,807	$279,006	$22,844
Mechanical-Federal	$37,196	$18,779	$41,011	$28,461	$51,247	$5,667
Mechanical-State	$22,768	$16,330	$35,277	$22,425	$44,704	$139
Mechanical-3rd	$16,145	$15,904	$28,826	$18,613	$36,948	$273
Dispersant-Federal	$15,390	$16,377	$29,167	$18,711	$37,730	$0
Dispersant-State	$18,729	$18,342	$34,288	$21,840	$44,088	$0
Dispersant-3rd	$15,390	$16,377	$29,167	$18,711	$37,730	$0

Shellfishing

Economic impacts of the oil spill scenarios on shellfishing were examined in two ways. The first method valued the amount (weight) of shellfish directly killed by the oil (Table 15) by wholesale market value (Table 16).

Table 15: Pounds of Shellfish Killed by Oil Spill Scenarios						
Response	Pounds of Shellfish Impacted					
	5th	50th	95th	Mean	Mean+2SD	Mean-2SD
No Response	21,457	13,861	14,066	16,461	33,230	1,972
Mechanical-Federal	1,496	6,780	4,382	4,219	12,649	0
Mechanical-State	1,219	6,209	2,621	4,003	9,492	0
Mechanical-3rd	1,306	5,986	2,075	3,122	8,832	0
Dispersant-Federal	4,974	6,039	4,205	5,073	12,394	0
Dispersant-State	2,359	6,649	3,164	4,057	10,160	0
Dispersant-3rd	1,413	6,900	2,018	3,443	10,070	5

Table 16: Shellfish Wholesale Prices		
Shellfish	**$/kg**	**$/lb**
Oyster	$2.23	$1.01
Clam	$5.95	$2.69
Mussel	$3.48	$1.57
Geoduck	$19.33	$8.75

Costs were pro-rated, assuming that the percentage of annual catch would be proportional to the annual harvest shown in Table 17. British Columbia shellfishing was determined to be $30 million annually (wholesale). Estimated shellfish catch losses are in Table 18.

Table 17: Washington Annual Shellfish Income			
Shellfish	**Annual Harvest**		**Annual Income**
	Pounds	**Kilograms**	
Oyster	77,000,000	34,841,629	$77,904,750
Clam	7,000,000	3,167,421	$18,886,000
Mussel	1,500,000	678,733	$2,360,750
Geoduck	500,000	226,244	$4,384,250
TOTAL	**86,000,000**	**38,914,027**	**$103,535,750**
(Weighted Average Income)	**$1.20/lb or $2.66/kg**		
Source: Puget Sound Action Team July 2003 *Shellfish Economy*. Wholesale costs adjusted to 2003 dollars.			

The second method involved mapping of shoreline and nearshore shellfishing areas (Figure 3) and determining what area percentages were impacted by oil at 0.01g/m^2 or higher using the SIMAP modeling (Table 19). Deeper areas used for geoduck shellfishing were also included (not shown in Figure 3). Shellfishing income was assumed to be reduced by percentage area impacted for four months. Results are in Table 20.

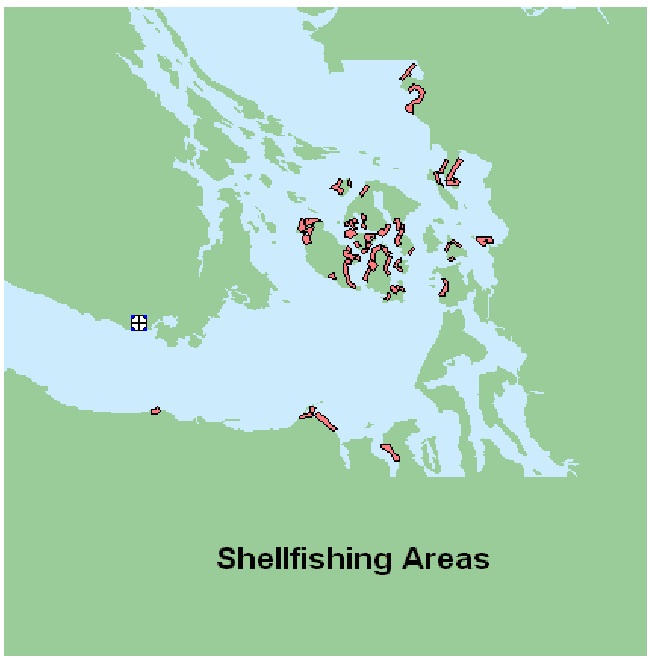

Figure 3: Shellfishing Areas (excluding subtidal geoducks) modeled

Table 18: Shellfishing Impact by Oil Spill Scenarios						
Response	**Wholesale Market Value of Killed Shellfish**					
	5th	**50th**	**95th**	**Mean**	**Mean+2SD**	**Mean-2SD**
No Response	$57,076	$36,870	$37,416	$43,787	$88,392	$5,244
Mechanical-Federal	$3,980	$18,034	$11,656	$11,223	$33,647	$0
Mechanical-State	$3,243	$16,516	$6,973	$10,649	$25,249	$0
Mechanical-3rd	$3,474	$15,924	$5,519	$8,306	$23,492	$0
Dispersant-Federal	$13,231	$16,065	$11,185	$13,494	$32,967	$0
Dispersant-State	$6,276	$17,687	$8,416	$10,793	$27,026	$0
Dispersant-3rd	$3,757	$18,354	$5,367	$9,160	$26,786	$13

Table 19: Shellfishing Areas Impacted by Oil Spill Scenarios						
Response	**% Total Intertidal Shellfishing Areas Impacted**					
	5th	**50th**	**95th**	**Mean**	**Mean+2SD**	**Mean-2SD**
No Response	10.6%	3.7%	3.8%	6.1%	4.0%	14.0%
Mechanical-Federal	0.5%	1.1%	2.2%	1.3%	0.9%	3.0%
Mechanical-State	0.3%	0.8%	1.8%	1.0%	0.8%	2.5%
Mechanical-3rd	0.3%	0.9%	1.3%	0.8%	0.5%	1.9%
Dispersant-Federal	0.3%	0.9%	1.1%	0.8%	0.4%	1.6%
Dispersant-State	0.3%	0.9%	1.8%	1.0%	0.8%	2.5%
Dispersant-3rd	0.3%	0.9%	1.1%	0.8%	0.4%	1.6%

Table 20: Shellfishing Impacts of Oil Spill Scenarios						
Response	**Cost of Shellfishing Closures[1]**					
	5th	**50th**	**95th**	**Mean**	**Mean+2SD**	**Mean-2SD**
No Response	$3,455,363	$1,206,117	$1,238,715	$1,988,463	$4,563,686	$1,303,910
Mechanical-Federal	$162,989	$358,575	$717,151	$423,771	$977,933	$293,380
Mechanical-State	$97,793	$260,782	$586,760	$325,978	$814,944	$260,782
Mechanical-3rd	$97,793	$293,380	$423,771	$260,782	$619,357	$162,989
Dispersant-Federal	$97,793	$293,380	$358,575	$260,782	$521,564	$130,391
Dispersant-State	$97,793	$293,380	$586,760	$325,978	$814,944	$260,782
Dispersant-3rd	$97,793	$293,380	$358,575	$260,782	$521,564	$130,391

Commercial Fishing

Commercial fishing (other than shellfishing) was also examined by two methods – direct impacts on fishing-catch wholesale losses, and by percentage area of impact (Figure 4) valued by annual commercial fishing income (daily fishing income of $4.4 million) for an estimated time of fishing ban of four months.

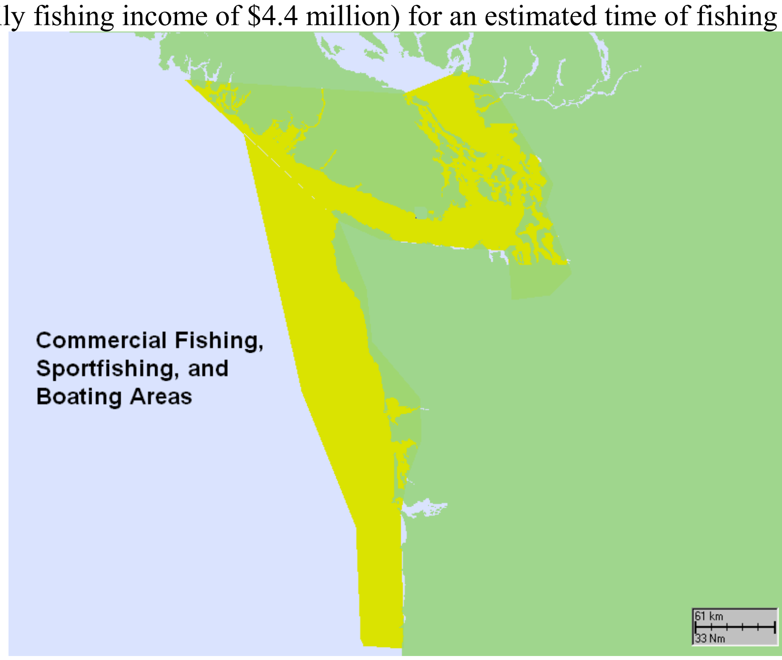

Figure 4: Commercial fishing, sportfishing and recreational boating areas in and around Washington State considered in spill scenario modeling.

The fishing-catch losses are shown in Table 21, with their corresponding wholesale values (estimated at $12 per kg or $5 per pound) in Table 22.

The estimated fishing area impacts by area (where floating oil met or exceeded 0.1 g/m^2) are shown in Table 23, with their corresponding fishing income values in Table 24.

Table 21: Pelagic and Demersal Fish Killed by Oil Spill Scenarios						
Response	Pounds of Pelagic and Demersal Fish Killed					
	5th	50th	95th	Mean	Mean+2SD	Mean-2SD
No Response	1,061	9,331	289	3,561	13,587	0
Mechanical-Federal	209	9,452	145	3,268	13,978	0
Mechanical-State	118	9,442	147	3,882	12,007	0
Mechanical-3rd	156	8,551	77	2,928	12,667	0
Dispersant-Federal	7,082	8,341	164	5,196	14,002	0
Dispersant-State	2,323	9,886	1,156	4,455	13,933	0
Dispersant-3rd	277	10,391	87	3,585	15,375	0

Table 22: Pelagic and Demersal Fish Killed by Oil Spill Scenarios						
Response	Wholesale Market Value of Killed Pelagic and Demersal Fish					
	5th	50th	95th	Mean	Mean+2SD	Mean-2SD
No Response	$12,737	$111,977	$3,469	$42,727	$163,039	$0
Mechanical-Federal	$2,508	$113,418	$1,739	$39,222	$167,737	$0
Mechanical-State	$1,411	$113,308	$1,762	$46,588	$144,086	$0
Mechanical-3rd	$1,875	$102,608	$925	$35,136	$152,006	$0
Dispersant-Federal	$84,989	$100,091	$1,965	$62,348	$168,020	$0
Dispersant-State	$27,880	$118,628	$13,869	$53,459	$167,201	$0
Dispersant-3rd	$3,322	$124,688	$1,039	$43,016	$184,499	$0

Table 23: Commercial Fishing Areas Impacted by Oil Spill Scenarios						
Response	% Area Coverage					
	5th	50th	95th	Mean	Mean+2SD	Mean-2SD
No Response	2.38%	1.10%	0.93%	1.47%	0.79%	3.06%
Mechanical-Federal	0.22%	0.26%	0.48%	0.32%	0.14%	0.60%
Mechanical-State	0.12%	0.23%	0.42%	0.26%	0.15%	0.56%
Mechanical-3rd	0.21%	0.23%	0.50%	0.32%	0.64%	0.00%
Dispersant-Federal	0.13%	0.40%	0.70%	0.41%	0.29%	0.99%
Dispersant-State	0.09%	0.22%	0.45%	0.25%	0.18%	0.62%
Dispersant-3rd						

Table 24: Commercial Fishing Losses for Oil Spill Scenarios						
Response	Commercial Fishing Income Lost ($ thousand)					
	5th	50th	95th	Mean	Mean+2SD	Mean-2SD
No Response	$125,660	$58,080	$49,100	$77,620	$161,570	$41,710
Mechanical-Federal	$11,620	$13,730	$25,340	$16,900	$31,680	$7,390
Mechanical-State	$6,340	$12,140	$22,180	$13,730	$29,570	$7,920
Mechanical-3rd	$11,090	$12,140	$26,400	$16,900	$33,790	$0
Dispersant-Federal	$6,860	$21,120	$36,960	$21,650	$52,270	$15,310
Dispersant-State	$4,750	$11,620	$23,760	$13,200	$32,740	$9,500
Dispersant-3rd						

Damage to fishing boats and fishing gear (gill nets and other equipment) were also considered in this analysis.

Fishing boat damage was assumed to be the equivalent of the cost to remove oil from the boats, depending on oil type, as shown in Table 25. The fishing gear damage was estimated at $1,000 per boat based on information from the Pacific Coast Fisherman's Association.

It was assumed that at any one time 70% of the fishing fleet would be in areas potentially vulnerable to oiling. The vessels were assumed to be evenly distributed throughout the assumed fishing waters in Figure 4. The percentage area coverage for each scenario was taken into account in determining impacts on vessels. The number of commercial fishing vessels was assumed to be 2,835 commercial fishing vessels out of Seattle and 1,522 out of Portland; 1,500 out of British Columbia (documented <5,000 GT self-propelled with fisheries endorsement, according to US Coast Guard Marine Safety Information System).

Table 25: Damage Costs for Commercial Fishing Vessels			
Oil Type	**Damage to Gillnets/Equipment**[1]	**Damage to Boats**[2]	**Total Damage to Commercial Fishing Fleet (4,000 Boats) If All Impacted**
Diesel	$1,000 *per boat*	$200 *per boat*	$4,800,000
Bunker C	$1,000 *per boat*	$500 *per boat*	$6,000,000
Crude Oil	$1,000 *per boat*	$300 *per boat*	$5,200,000
[1]Based on cost of gillnets and other equipment as per Pacific Coast Fisherman's Association. [2]Based on cost of boat cleanup as per personal communications with marina representatives and factors of oil persistence based on oil type.			

Commercial fishing boat damages are shown in Table 26.

Table 26: Commercial Fishing Boat Damages for Oil Spill Scenarios						
Response	**Commercial Fishing Damage**					
	5th	**50th**	**95th**	**Mean**	**Mean+2SD**	**Mean-2SD**
No Response	$93,903	$43,401	$36,693	$57,999	$120,732	$31,169
Mechanical-Federal	$8,680	$10,258	$18,938	$12,626	$23,673	$5,524
Mechanical-State	$4,735	$9,075	$16,571	$10,258	$22,095	$5,918
Mechanical-3rd	$8,286	$9,075	$19,728	$12,626	$25,251	$0
Dispersant-Federal	$5,129	$15,782	$27,619	$16,177	$39,060	$11,442
Dispersant-State	$3,551	$8,680	$17,755	$9,864	$24,462	$7,102
Dispersant-3rd						
Based on percentage of area impacted, size of fishing fleet (assuming 70% out in water at any one time) and costs shown in Table 25.						

Tribal Nations

Impacts to Tribal Nations areas (shown in Figure 5), were recorded in terms of area of oiling. The results are shown in Table 27. No attempt was made to place any value on this oiling, as according to several sources in state agencies involved in Tribal Nations affairs, Tribal spokespersons have noted that the value of this land and adjacent waters is not quantifiable due to the sacred, moral, and ethical values associated with these lands and waters.

Tribal members may experience loss of income associated with commercial fishing. By treaty agreement, 50% of all commercial fishing income goes to tribes. 50% of the losses noted under Commercial Fishing and Shellfishing would impact Tribal Nations. Total income losses for tribes are shown in Table 28. Note that any economic impacts on the Tribal Nations in terms of lost wages or livelihood may be somewhat offset by income from shoreline cleanup and other oil spill response activities, which often involve the hiring of local workers. Impacts to *subsistence* fishing associated with Tribal Nations are described under Subsistence Fishing.

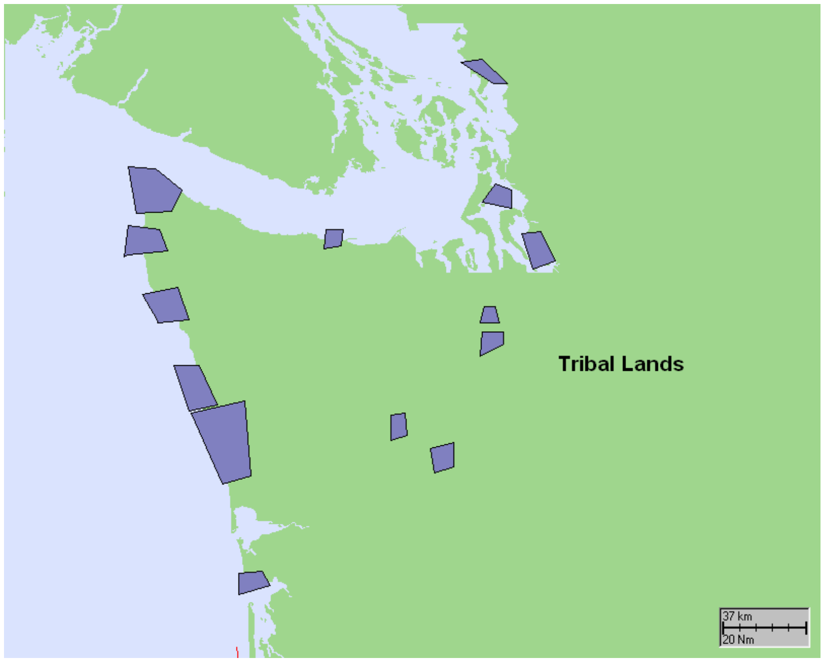

Figure 5: Tribal Nations locations included in modeling.

Table 27: Oiling of Tribal Nations Lands by Oil Spill Scenarios						
Response	% Area Covered by Oil (> 0.01 g/m^2)					
	5th	50th	95th	Mean	Mean+2SD	Mean-2SD
No Response	0.59%	0.78%	0.51%	0.63%	0.14%	0.91%
Mechanical-Federal	0.00%	0.05%	0.00%	0.02%	0.03%	0.08%
Mechanical-State	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Mechanical-3rd	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Dispersant-Federal	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Dispersant-State	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Dispersant-3rd	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

Table 28: Fishing Income Losses of Tribal Nations Lands by Oil Spill Scenarios						
Response	Dollars Income Lost (50% of Commercial Fishing Catch)					
	5th	50th	95th	Mean	Mean+2SD	Mean-2SD
No Response	$6,369	$55,989	$1,735	$21,364	$81,520	$0
Mechanical-Federal	$1,254	$56,709	$870	$19,611	$83,869	$0
Mechanical-State	$706	$56,654	$881	$23,294	$72,043	$0
Mechanical-3rd	$938	$51,304	$463	$17,568	$76,003	$0
Dispersant-Federal	$42,495	$50,046	$983	$31,174	$84,010	$0
Dispersant-State	$13,940	$59,314	$6,935	$26,730	$83,601	$0
Dispersant-3rd	$1,661	$62,344	$520	$21,508	$92,250	$0

Subsistence Fishing

Fishing impacts include those on vulnerable populations, primarily Tribal Nations, who depend on subsistence fishing for vital protein intake. Tribal population census figures are in Table 29. Annual fish harvest and estimated subsistence fish consumption are in Tables 30 – 31. Assuming an annual intake of 55 grams per day, the number of days of subsistence fish loss are in Table 32 and the pounds of fish lost due to fishing bans are in Table 33 (percent losses are in Table 34). The impact of protein loss on Tribal children under two who could suffer life-long impacts on IQ and earning power are in Table 35.

Table 29: Washington Coastal Tribal Nation Populations[1]

Tribe	Total Population	Children under 2 yrs.	Children 2 – 18 yrs.
Hoh	102	14[2]	52[2]
Lower Elwha	375	5	163
Lummi	4,193	93	1,183
Makah	1,356	61	433
Nisqually	591	12	199
Port Gamble	698	24	258
Quileute	364	18	108
Quinault	1,370	59	454
Shoalwater	70	5[2]	15[2]
Skokomish	704	16	211
Swinomish	2,664	41	479
Tulalip	9,246	255	2,397
TOTAL	**12,487**	**348**	**5,952**

[1]Source: US Census Data 2000. [2]Hoh and Shoalwater child data are for children under 5 years and 5 to 18 years.

Table 30: Estimated Annual Treaty Tribe Fishing Harvest

Fish Type	Annual Pounds Harvested
Manila and Littleneck Clams	750,000 lbs.
Geoduck Clams	2,200,000 lbs.
Oysters	1,100,000 lbs.
Crabs	5,200,000 lbs.
Shrimp	115,111 lbs.
Salmon	10,000,000 lbs.[1] (2,000,000 fish)

Source: Northwest Indian Fisheries *Commission Report from the Treaty Indian Tribes in Western Washington 2003.* [1]Estimated weight based on approximately 2 million fish reported caught.

Table 31: Fish Consumption Rates for Various Fisher Populations

Data Source	Recreational *(grams/day)*	Subsistence *(grams/day)*	Tribal Fishers *(grams/day)*	Tribal *(grams/day)*	Basis for Consumption Rate
US EPA	17.5[1]	142.4[1]	70 (mean)[2] 170 (95^{th})[2]	NA	Continuing Survey of Food Intake by Individuals (USDA/ARS 1998)
Harris and Harper (1997)	NA	NA	540 (fresh, dried, and smoked)	NA	Surveyed Confederated Tribes of Umatilla Indian Reservation
CRITFC (1994)	NA	NA	NA	59 (mean) 170 (95^{th}) 390 (99^{th})	Surveyed Umatilla, Nez Pierce, Yakama, Warm Springs Tribes
Toy *et al.* (1996)	NA	NA	NA	53 (males) 34 (females)	Surveyed Tulalip Tribe
	NA	NA	NA	66 (males) 25 (females)	Surveyed Squaxin Island Tribe

Source: US EPA 2000. NA = not available. [1]Values revised in 3rd Edition of Volume 1 of US EPA 2000*a*. [2]Values from EPA's Exposure Factors Handbook (US EPA 1997)

Table 32: Subsistence Fishing Losses of Tribal Nations Lands by Oil Spill Scenarios						
Response	Days of Subsistence Food Supply Killed Directly by Impacts of Oil Spill					
	5th	50th	95th	Mean	Mean+2SD	Mean-2SD
No Response	14.8	15.3	9.5	13.2	30.9	1.3
Mechanical-Federal	1.1	10.7	3.0	4.9	17.6	0.0
Mechanical-State	0.9	10.3	1.8	5.2	14.2	0.0
Mechanical-3rd	1.0	9.6	1.4	4.0	14.2	0.0
Dispersant-Federal	7.9	9.5	2.9	6.8	17.4	0.0
Dispersant-State	3.1	10.9	2.8	5.6	15.9	0.0
Dispersant-3rd	1.1	11.4	1.4	4.6	16.8	0.0

Table 33: Subsistence Fishing Losses of Tribal Nations Lands by Oil Spill Scenarios						
Response	Pounds Subsistence Fishing Loss Due to Fishing Ban[1]					
	5th	50th	95th	Mean	Mean+2SD	Mean-2SD
No Response	138,267	63,905	54,029	85,400	177,772	45,895
Mechanical-Federal	12,781	15,105	27,886	18,591	34,857	8,133
Mechanical-State	6,971	13,362	24,400	15,105	32,533	8,714
Mechanical-3rd	12,200	13,362	29,048	18,591	37,181	0
Dispersant-Federal	7,552	23,238	40,667	23,819	57,514	16,848
Dispersant-State	5,229	12,781	26,143	14,524	36,019	10,457
Dispersant-3rd	138,267	63,905	54,029	85,400	177,772	45,895
[1]Four-month fishing ban assumed.						

Table 34: Subsistence Fishing Losses of Tribal Nations Lands by Oil Spill Scenarios						
Response	% Subsistence Fishing Loss Due to Fishing Ban (food lost/food required)[1]					
	5th	50th	95th	Mean	Mean+2SD	Mean-2SD
No Response	38.0%	17.6%	14.8%	23.5%	12.6%	48.9%
Mechanical-Federal	3.5%	4.2%	7.7%	5.1%	2.2%	9.6%
Mechanical-State	1.9%	3.7%	6.7%	4.2%	2.4%	8.9%
Mechanical-3rd	3.4%	3.7%	8.0%	5.1%	10.2%	0.0%
Dispersant-Federal	2.1%	6.4%	11.2%	6.5%	4.6%	15.8%
Dispersant-State	1.4%	3.5%	7.2%	4.0%	2.9%	9.9%
Dispersant-3rd						
[1]Assumes four-month ban on fishing and shellfishing and that Tribal populations entitled to 50% catch.						

Table 35: Impact of Subsistence Fishing Losses of Tribal Nations Lands by Oil Spill Scenarios						
Response	Lost Earning Power Due to IQ Reduction of Tribal Children Under 2					
	5th	50th	95th	Mean	Mean+2SD	Mean-2SD
No Response	$3,594,329	$1,669,494	$1,403,892	$2,229,154	$4,638,537	$1,195,206
Mechanical-Federal	$332,002	$398,402	$730,404	$483,774	$910,633	$208,687
Mechanical-State	$180,229	$350,973	$635,546	$398,402	$844,233	$227,658
Mechanical-3rd	$322,516	$350,973	$758,861	$483,774	$967,548	$0
Dispersant-Federal	$199,201	$607,089	$1,062,405	$616,574	$1,498,750	$436,345
Dispersant-State	$132,801	$332,002	$682,975	$379,430	$939,090	$275,087
Dispersant-3rd	$3,604,589	$1,669,494	$1,403,892	$2,229,154	$4,638,537	$1,195,206
Assumes loss of 4 IQ pts from 50% 4-month protein reduction; $723,000 lifetime earnings per child with 2% reduction earning power per IQ pt (Gross, *et al*. 2002; Schűrch 1995; Wachs 1995; VanDuzen *et al.* 1969; Pollitt 2000).						

Parks and Recreation

Impacts on state and national parks and recreation areas were considered from the perspective of "lost use" and lost income from these activities. National park areas included are shown in Figure 6, with their corresponding visitor days and income in Table 36. The analogous information for state parks is shown in Figure 7 and Table 37.

Impacts were considered by percentage of area impacted by 1 gram/m[r] of shoreline oil. Results are shown in Tables 38 – 43. Lost-use values were based on federal standards (US Army Corps of Engineers 2001).

Figure 6: National Park Areas

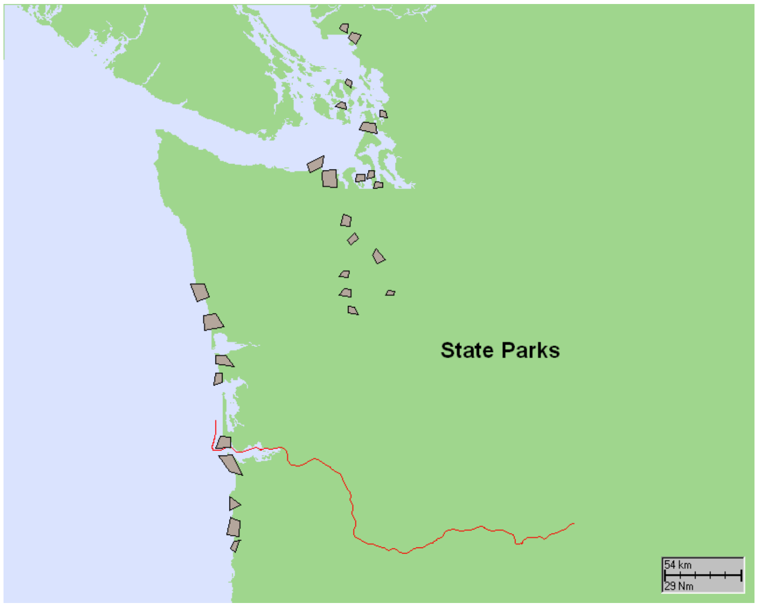

Figure 7: State Parks

Table 36: Coastal National Parks Visits and Spending				
National Park	**Visitor Days**		**Spending**	
	Annual	**Daily**	**Annual**	**Daily**
Fort Vancouver NHS	42,756	117	$17,700,000	$48,493
Olympic NP	1,620,628	4,440	$91,600,000	$250,959
San Juan Islands NHP	18,464	51	$17,100,000	$46,849
Fort Clatsop NM	31,826	87	$6,900,000	$18,904
Pacific Rim NP (Canada)	800,000	2,192	$16,000,000	$43,836
Total	**2,513,674**	**6,887**	**$149,300,000**	**$409,041**
Sources: National Parks Service, Parks Canada				

Table 37: Coastal State Park Visits, Spending and Earnings						
County	**Visitor Days**		**Visitor Spending**		**Earnings**	
	Annual	**Daily**	**Annual**	**Daily**	**Annual**	**Daily**
Clallam	518,923	1,422	$6,400,000	$17,534	$1,200,000	$3,288
Clark	140,195	384	$11,200,000	$30,685	$1,700,000	$4,658
Cowlitz	449,152	1,231	$8,800,000	$24,110	$1,300,000	$3,562
Douglas	242,347	664	$64,800,000	$177,534	$14,300,000	$39,178
Grays Harbor	6,518,830	17,860	$45,600,000	$124,932	$11,100,000	$30,411
Island	4,586,870	12,567	$26,300,000	$72,055	$6,000,000	$16,438
Jefferson	2,718,102	7,447	$70,600,000	$193,425	$12,100,000	$33,151
King	4,022,701	11,021	$20,200,000	$55,342	$4,300,000	$11,781
Kitsap	1,639,523	4,492	$8,100,000	$22,192	$1,700,000	$4,658
Mason	1,791,820	4,909	$18,800,000	$51,507	$4,100,000	$11,233
Pacific	4,782,443	13,103	$45,300,000	$124,110	$10,100,000	$27,671
Pierce	913,929	2,504	$20,600,000	$56,438	$3,300,000	$9,041
San Juan	1,242,993	3,405	$13,400,000	$36,712	$300,000	$822
Skagit	537,660	1,473	$8,300,000	$22,740	$1,500,000	$4,110
Skamania	419,804	1,150	$4,100,000	$11,233	$900,000	$2,466
Snohomish	2,287,921	6,268	$33,900,000	$92,877	$6,100,000	$16,712
Thurston	649,846	1,780	$10,600,000	$29,041	$1,900,000	$5,205
Whatcom	2,916,092	7,989	$32,600,000	$89,315	$6,800,000	$18,630
Washington TOTAL	**36,379,151**	**99,669**	**$449,600,000**	**$1,231,781**	**$88,700,000**	**$243,014**
Sources: Washington State Parks and Recreation Commission; Oregon State Park Commission						

Table 38: Areas of State Parks Impacted Oil Spill Scenarios						
Response	**% Area Covered by Oil (> 0.01 g/m^2)**					
	5th	**50th**	**95th**	**Mean**	**Mean+2SD**	**Mean-2SD**
No Response	2.95%	1.38%	3.16%	2.50%	4.44%	0.55%
Mechanical-Federal	0.01%	0.33%	0.90%	0.42%	1.32%	0.00%
Mechanical-State	0.00%	0.29%	1.02%	0.44%	1.49%	0.00%
Mechanical-3rd	0.01%	0.20%	0.78%	0.33%	1.14%	0.00%
Dispersant-Federal	0.00%	0.21%	0.77%	0.33%	1.12%	0.00%
Dispersant-State	0.00%	0.29%	0.80%	0.36%	1.17%	0.00%
Dispersant-3rd	0.00%	0.21%	0.77%	0.33%	1.12%	0.00%
[1]Assumes four-month ban on fishing and shellfishing and that Tribal populations entitled to 50% catch.						

Table 39: Impact on State Parks Impacted Oil Spill Scenarios						
Response	Lost Use for Duration of Spill Response and Oiled Areas					
	5th	50th	95th	Mean	Mean+2SD	Mean-2SD
No Response	$1,368,784	$640,313	$1,466,223	$1,159,987	$2,060,136	$255,197
Mechanical-Federal	$4,640	$153,118	$417,595	$194,878	$612,473	$0
Mechanical-State	$0	$134,558	$473,275	$204,158	$691,352	$0
Mechanical-3rd	$4,640	$92,799	$361,916	$153,118	$528,954	$0
Dispersant-Federal	$0	$97,439	$357,276	$153,118	$519,674	$0
Dispersant-State	$0	$134,558	$371,196	$167,038	$542,874	$0
Dispersant-3rd	$0	$97,439	$357,276	$153,118	$519,674	$0

Table 40: Impact on State Parks Impacted Oil Spill Scenarios						
Response	Lost Income for Duration of Spill Response and Oiled Areas					
	5th	50th	95th	Mean	Mean+2SD	Mean-2SD
No Response	$512,139	$239,577	$548,596	$434,016	$770,812	$95,484
Mechanical-Federal	$1,736	$57,290	$156,246	$72,915	$229,160	$0
Mechanical-State	$0	$50,346	$177,079	$76,387	$258,674	$0
Mechanical-3rd	$1,736	$34,721	$135,413	$57,290	$197,911	$0
Dispersant-Federal	$0	$36,457	$133,677	$57,290	$194,439	$0
Dispersant-State	$0	$50,346	$138,885	$62,498	$203,119	$0
Dispersant-3rd	$0	$36,457	$133,677	$57,290	$194,439	$0
Lost-use values based on US Army Corps of Engineers - $6.50 per person-day. Assumes 2 months lost use for crude oil spills, 3 months for Bunker spills and 1 month for diesel spills.						

Table 41: Areas of National Parks Impacted Oil Spill Scenarios						
Response	% Area Covered by Oil (> 0.01 g/m^2)					
	5th	50th	95th	Mean	Mean+2SD	Mean-2SD
No Response	1.41%	0.00%	0.00%	0.47%	2.10%	0.81%
Mechanical-Federal	0.24%	0.00%	0.00%	0.08%	0.36%	0.14%
Mechanical-State	0.01%	0.00%	0.00%	0.00%	0.02%	0.01%
Mechanical-3rd	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Dispersant-Federal	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Dispersant-State	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Dispersant-3rd	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

Table 42: Impact on National Parks Impacted Oil Spill Scenarios						
Response	Lost Use for Duration of Spill Response and Oiled Areas					
	5th	50th	95th	Mean	Mean+2SD	Mean-2SD
No Response	$37,872	$0	$0	$12,624	$56,405	$21,756
Mechanical-Federal	$6,446	$0	$0	$2,149	$9,669	$3,760
Mechanical-State	$269	$0	$0	$0	$537	$269
Mechanical-3rd	$0	$0	$0	$0	$0	$0
Dispersant-Federal	$0	$0	$0	$0	$0	$0
Dispersant-State	$0	$0	$0	$0	$0	$0
Dispersant-3rd	$0	$0	$0	$0	$0	$0
Lost-use values based on US Army Corps of Engineers - $6.50 per person-day. Assumes 2 months lost use for crude oil spills, 3 months for Bunker spills and 1 month for diesel spills.						

Table 43: Impact on National Parks Impacted Oil Spill Scenarios						
Response	Lost Income for Duration of Spill Response and Oiled Areas					
	5th	50th	95th	Mean	Mean+2SD	Mean-2SD
No Response	$311,072	$0	$0	$103,691	$463,298	$178,701
Mechanical-Federal	$52,948	$0	$0	$17,649	$79,423	$30,887
Mechanical-State	$2,206	$0	$0	$0	$4,412	$2,206
Mechanical-3rd	$0	$0	$0	$0	$0	$0
Dispersant-Federal	$0	$0	$0	$0	$0	$0
Dispersant-State	$0	$0	$0	$0	$0	$0
Dispersant-3rd	$0	$0	$0	$0	$0	$0
Parks income assumed to be $59 per day.						

Recreational Boating

Recreational boating impacts were based on lost-use (using federal methods in US Army Corps of Engineers 2001) and percentage areas impacted. Boating areas are assumed to be as in Figure 4. It was assumed that there would be six days of boating prohibition for bunker and crude oil spills and two days for diesel spills. It was assumed that 20% of boatowners would want to engage in recreational boating activities during the time period of the oil spill response operations. Potential boating losses are shown in Table 44 based on the vessel registrations in Table 45.

Table 44: Total Small Vessels in Coastal Counties of Washington			
Ports Area	**County**	**TOTAL**	**Potential Lost-Use Per Day[1] (Total Impact)**
Portland	**Clark***	25,901	$168,357
	Cowlitz*	9,863	$64,110
	Klickitat*	1,551	$10,082
	Pacific*	2,984	$19,396
	Skamania*	993	$6,455
	Wahkaikum*	961	$6,247
	Area TOTAL	**42,253**	**$274,645**
Ports North	**San Juan***	5,231	$34,002
	Skagit*	15,656	$101,764
	Whatcom*	16,189	$105,229
	Area TOTAL	**37,076**	**$240,994**
Ports South	**Island***	10,304	$66,976
	Jefferson*	5,370	$34,905
	King*	102,388	$665,522
	Kitsap*	22,926	$149,019
	Mason*	9,440	$61,360
	Pierce*	51,255	$333,158
	Snohomish*	49,229	$319,989
	Thurston*	18,742	$121,823
	Area TOTAL	**269,654**	**$1,752,751**
Str Juan de Fuca South	**Clallam***	9,304	$60,476
	Area TOTAL	9,304	**$60,476**
TOTAL		**358,287**	**$2,328,866**
Based on vessel registrations. [1]Based on US Army Corps of Engineers lost-use value of $6.50 per day.			

The estimated costs of lost-use for recreational boating are shown in Table 46.

Table 45: Recreational Vessels in Washington State			
County (*Coastal)	**Registered**	**Not Registered**	**TOTAL**
Adams	723	489	1,212
Asotin	944	964	1,908
Benton	8,679	4,513	13,192
Chelan	4,742	2,595	7,337
Clallam*	5,183	4,121	9,304
Clark*	15,163	10,738	25,901
Columbia	283	187	470
Cowlitz*	6,023	3,840	9,863
Douglas	2,128	1,159	3,287
Ferry	408	360	768
Franklin	2,266	1,364	3,630
Garfield	178	157	335
Grant	4,783	2,663	7,446
Grays Harbor*	4,148	3,458	7,606
Island*	6,040	4,264	10,304
Jefferson*	3,104	2,266	5,370
King*	63,751	38,637	102,388
Kitsap*	13,368	9,558	22,926
Kittitas	1,545	912	2,457
Klickitat*	821	730	1,551
Lewis	3,275	2,407	5,682
Lincoln	1,268	774	2,042
Mason*	5,404	4,036	9,440
Okanogan	1,911	1,499	3,410
Pacific*	1,559	1,425	2,984
Pend Oreille	1,071	849	1,920
Pierce*	31,261	19,994	51,255
San Juan*	3,152	2,079	5,231
Skagit*	9,653	6,003	15,656
Skamania*	528	465	993
Snohomish*	30,056	19,173	49,229
Spokane	16,592	14,516	31,108
Stevens	3,349	2,227	5,576
Thurston*	11,063	7,679	18,742
Wahkaikum*	539	422	961
Walla Walla	2,038	1,246	3,284
Whatcom*	9,391	6,798	16,189
Whitman	1,127	1,002	2,129
Yakima	7,566	5,304	12,870
DOL	42	153	195
TOTAL	**285,125**	**191,026**	**476,151**
Source: Washington Vessel Registrations and Licenses			

Table 46: Impact on Recreational Boating Areas Impacted Oil Spill Scenarios						
Response	**Lost Use for Duration of Spill Response and Oiled Areas**					
	5th	**50th**	**95th**	**Mean**	**Mean+2SD**	**Mean-2SD**
No Response	$2,556	$1,431	$1,183	$1,723	$3,186	$260
Mechanical-Federal	$292	$215	$469	$325	$586	$65
Mechanical-State	$179	$187	$404	$256	$511	$2
Mechanical-3rd	$127	$182	$330	$213	$423	$3
Dispersant-Federal	$121	$187	$334	$214	$432	$0
Dispersant-State	$147	$210	$392	$250	$504	$0
Dispersant-3rd	$121	$187	$334	$214	$432	$0
Lost-use values based on US Army Corps of Engineers - $6.50 per person-day. Assumes 6 days no boating for bunker, crude spills and 2 days for diesel. Degree of prohibition based on coverage of oil as in ports areas. Assumes 20% of boatowners would want to boat during the time period of response operations.						

Recreational Fishing (Sportfishing)

Impacts to recreational fishing (or sportfishing) were considered based on lost-use and lost sportfishing-related income. Sportfishing areas were assumed to be analogous to commercial fishing as in Figure 4.

Recreational marine fishing visitor days are shown in Table 47. The corresponding lost-use values (based on federal standards in Army Corps of Engineers 2001), based on a four-month fishing ban are shown in Table 48. Potential spending losses by sportfishermen are shown in Tables 49 and 50. Results are shown in Table 51.

Table 47: Recreational Marine Fishing Visits		
Year	**Visits**	
	Annual	**Daily (Visitor Days)**
1993	NA	NA
1994	NA	NA
1995	NA	NA
1997	321,069	880
1998	325,772	893
1999	328,747	901
2000	422,704	1,158
2001	570,585	1,563
2002	413,561	1,133
Average	**397,073**	**1,088**
SD	**96,503**	**264**
Source: National Marine Fisheries		

Table 48: Impact on Recreational Fishing by Oil Spill Scenarios						
Response	**Lost Use for Duration of Spill Response and Fishing Ban**					
	5th	**50th**	**95th**	**Mean**	**Mean+2SD**	**Mean-2SD**
No Response	$404	$187	$158	$250	$519	$134
Mechanical-Federal	$37	$44	$81	$54	$102	$24
Mechanical-State	$20	$39	$71	$44	$95	$25
Mechanical-3rd	$36	$39	$85	$54	$109	$0
Dispersant-Federal	$22	$68	$119	$70	$168	$49
Dispersant-State	$15	$37	$76	$42	$105	$31
Dispersant-3rd	$404	$187	$158	$250	$519	$134
Lost-use values based on US Army Corps of Engineers - $6.50 per person-day. Assumes four-month fishing ban.						

Table 49: Trip-Related Expenditures for Recreational Fishing		
Expenditure Type	**Expenditures**	
	Total Annual	**Daily**
Private Transportation	$41,039,000	$112,436
Food	$15,329,000	$41,997
Lodging	$6,746,000	$18,482
Public Transportation	$7,863,000	$21,542
Boat Fuel	$11,792,000	$32,307
Charter Fees	$2,834,000	$7,764
Access Boat Launching	$3,203,000	$8,775
Equipment Rental	$1,480,000	$4,055
Bait & Ice	$4,435,000	$12,151
Total	**$94,727,000**	**$259,526**
Source: Gentner, *et al.* 2000		

Table 50: Annual Expenditures for Recreational Fishing		
Expenditure Type	**Expenditures**	
	Total Annual[1]	**Daily Business Delay Interest** [2]
Rods and Reels	$40,768,000	$21
Other Tackle	$41,141,000	$21
Gear	$9,610,000	$5
Camping Equipment	$6,710,000	$3
Binoculars	$1,581,000	$1
Clothing	$6,597,000	$3
Magazines	$1,201,000	$1
Club Dues	$768,000	$0
License Fees	$24,574,000	$13
Boat Accessories	$118,836,000	$62
Boat Purchase	$271,210,000	$141
Boat Maintenance	$114,332,000	$60
Fishing Vehicle	$495,663,000	$258
Fishing Vehicle Maintenance	$100,661,000	$52
Vacation Home	$77,775,000	$40
Vacation Home Maintenance	$11,858,000	$6
Total	**$1,401,065,000**	**$729**
[1]Source: Gentner, *et al.* 2000. [2]Interest for assumed delay on business (annual 7%, daily 0.019%).		

Table 51: Impact on Recreational Fishing by Oil Spill Scenarios						
Response	**Lost Spending Income for Duration of Spill Response and Fishing Ban**					
	5th	**50th**	**95th**	**Mean**	**Mean+2SD**	**Mean-2SD**
No Response	$743,288	$343,537	$290,445	$459,090	$955,656	$246,722
Mechanical-Federal	$68,707	$81,200	$149,907	$99,938	$187,384	$43,723
Mechanical-State	$37,477	$71,830	$131,169	$81,200	$174,891	$46,846
Mechanical-3rd	$65,584	$71,830	$156,153	$99,938	$199,876	$0
Dispersant-Federal	$40,600	$124,922	$218,614	$128,045	$309,183	$90,569
Dispersant-State	$28,108	$68,707	$140,538	$78,077	$193,630	$56,215
Dispersant-3rd	$743,288	$343,537	$290,445	$459,090	$955,656	$246,722

Wildlife Viewing and Hunting

To estimate the reduction in wildlife viewing and hunting expenditures (Table 52), it was assumed that viewing and hunting opportunities would be directly related to the percent total area covered by oil. It was assumed that the areas would be impacted for a total of four months, analogous to the commercial and recreational fishing ban. The results are shown in Tables 53 and 54.

Table 52: Wildlife Viewing Expenditures in Washington			
Type	**Annual Spending**	**Estimated Coastal Spending**	**Estimated Daily Coastal Spending**
Wildlife Viewing	$980,000,000	$392,000,000	$1,073,973
Hunting	$350,000,000	$35,000,000	$95,890
Source: Washington Dept. of Fish and Wildlife			

Another methodology is to look at the value of specific species of wildlife that are of interest to wildlife viewers and hunters and that are impacted by the oil spill scenarios Wildlife injuries are shown in Table 55 for all the oil spill scenarios. The injuries for waterfowl are expected to affect both wildlife viewers and hunters, while the shorebird injuries are assumed to affect only wildlife viewers. There are insignificant impacts on mammals and other bird species. These impacts are not factored into this analysis.

The estimates costs for hunting opportunity losses on a per-waterfowl individual basis are shown in Table 56. Bird and wildlife individual injuries are shown in Tables 57 and 58. No estimates of cost per bird or per wildlife individual for the purposes of bird-watching or wildlife-viewing were available.

Table 53: Lost Wildlife Spending by Oil Spill Scenarios: Wildlife Viewing						
Response	**Lost Spending on Wildlife Viewing Activities**					
	5th	**50th**	**95th**	**Mean**	**Mean+2SD**	**Mean-2SD**
No Response	$3,067,267	$1,417,644	$1,198,554	$1,894,488	$3,943,629	$1,018,126
Mechanical-Federal	$283,529	$335,080	$618,608	$412,406	$773,261	$180,427
Mechanical-State	$154,652	$296,417	$541,282	$335,080	$721,710	$193,315
Mechanical-3rd	$270,641	$296,417	$644,384	$412,406	$824,811	$0
Dispersant-Federal	$167,540	$515,507	$902,137	$528,395	$1,275,880	$373,743
Dispersant-State	$115,989	$283,529	$579,945	$322,192	$799,036	$231,978
Dispersant-3rd	$3,067,267	$1,417,644	$1,198,554	$1,894,488	$3,943,629	$1,018,126

Table 54: Lost Wildlife Spending by Oil Spill Scenarios: Hunting						
Response	**Lost Spending on Hunting Activities**					
	5th	**50th**	**95th**	**Mean**	**Mean+2SD**	**Mean-2SD**
No Response	$273,862	$126,575	$107,013	$169,150	$352,108	$90,904
Mechanical-Federal	$25,315	$29,918	$55,233	$36,822	$69,041	$16,110
Mechanical-State	$13,808	$26,466	$48,329	$29,918	$64,438	$17,260
Mechanical-3rd	$24,164	$26,466	$57,534	$36,822	$73,644	$0
Dispersant-Federal	$14,959	$46,027	$80,548	$47,178	$113,917	$33,370
Dispersant-State	$10,356	$25,315	$51,781	$28,767	$71,342	$20,712
Dispersant-3rd	$273,862	$126,575	$107,013	$169,150	$352,108	$90,904

Table 55: Injured Waterfowl in Oil Spill Scenarios						
Response	Estimated Number of Waterfowl Injured					
	5th	50th	95th	Mean	Mean+2SD	Mean-2SD
No Response	49,889	20,702	16,972	29,188	65,236	0
Mechanical-Federal	4,148	3,055	6,660	4,621	8,317	925
Mechanical-State	2,515	2,649	5,724	4,430	9,749	0
Mechanical-3rd	1,768	2,595	4,667	3,010	5,996	23
Dispersant-Federal	3,741	2,888	7,408	4,679	9,482	0
Dispersant-State	2,058	2,979	5,559	3,532	7,162	0
Dispersant-3rd	1,683	2,666	4,722	3,024	6,126	0

Table 56: Hunting Losses Due to Injured Waterfowl in Oil Spill Scenarios						
Response	Hunting Losses Due to Injured Waterfowl[1]					
	5th	50th	95th	Mean	Mean+2SD	Mean-2SD
No Response	$4,290,440	$1,780,407	$1,459,634	$2,510,160	$5,610,335	$0
Mechanical-Federal	$356,754	$262,727	$572,725	$397,402	$715,294	$79,510
Mechanical-State	$216,274	$227,783	$492,292	$380,969	$838,412	$0
Mechanical-3rd	$152,040	$223,129	$401,332	$258,834	$515,682	$1,985
Dispersant-Federal	$321,701	$248,367	$637,087	$402,385	$815,462	$0
Dispersant-State	$176,987	$256,187	$478,096	$303,757	$615,935	$0
Dispersant-3rd	$144,734	$229,242	$406,118	$260,031	$526,799	$0

Table 57: Total Injured Birds in Oil Spill Scenarios						
Response	Estimated Total Number of Birds Injured					
	5th	50th	95th	Mean	Mean+2SD	Mean-2SD
No Response	55,532	23,097	19,243	32,624	72,489	0
Mechanical-Federal	4,578	3,445	7,548	5,190	9,428	953
Mechanical-State	2,752	2,971	6,437	4,904	10,725	0
Mechanical-3rd	1,942	2,907	5,242	3,364	6,757	0
Dispersant-Federal	4,125	3,244	8,358	5,242	10,710	0
Dispersant-State	2,255	3,332	6,253	3,947	8,084	0
Dispersant-3rd	1,845	2,991	5,301	3,379	6,900	0

Table 58: Total Injured Wildlife in Oil Spill Scenarios (Includes Birds)						
Response	Estimated Total Number of Wildlife Injured (Includes Birds)					
	5th	50th	95th	Mean	Mean+2SD	Mean-2SD
No Response	55,536	23,098	19,244	32,626	72,493	0
Mechanical-Federal	4,579	3,446	7,548	5,191	9,429	953
Mechanical-State	2,752	2,971	6,437	4,904	10,726	0
Mechanical-3rd	1,943	2,907	5,243	3,364	6,758	0
Dispersant-Federal	4,125	3,244	8,358	5,243	10,711	0
Dispersant-State	2,256	3,333	6,254	3,947	8,085	0
Dispersant-3rd	1,845	2,991	5,301	3,379	6,900	0

Tourism Impacts

Impacts of the oil spill scenarios on the area's tourism (other than visits to national and state parks) were measured by looking at percentage area coverage of the tourist areas shown in Figure 8. It was assumed that 30% of coastal county tourist spending would be impacted for a total of 30 days for diesel spills, 60 days for crude oil spills, and 90 days for bunker spills, based on the areas directly impacted by oil at concentrations of greater than 1 g/m^2 on the shoreline (visible oiling). The time of impact is related to the estimated time to cleanup the oil from impacted shorelines and for tourists to return to those areas. The estimated daily tourist income is shown in Table 59. The impacted areas are shown in Table 60. The corresponding tourist spending and income losses are shown in Table 61.

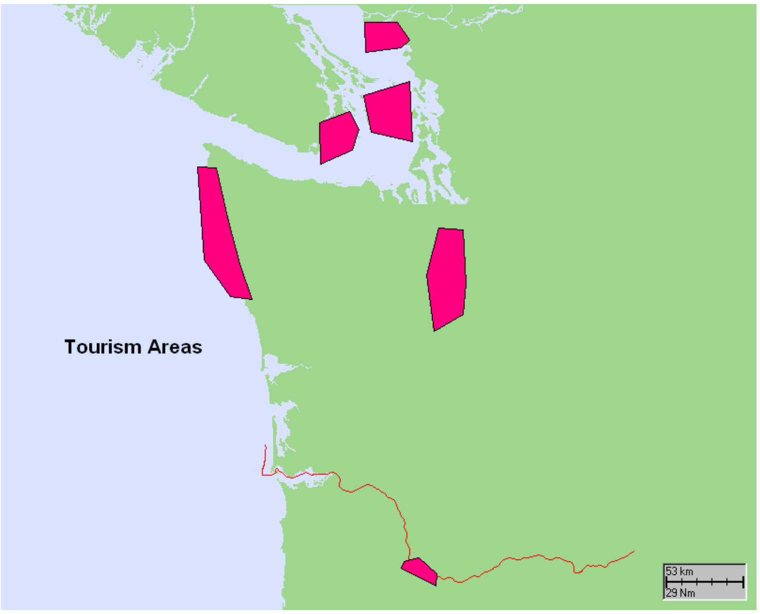

Figure 8: Most-Visited Coastal Tourist Areas.

Table 59: Estimated Daily Tourist Income By Coastal County and Tourism Area		
County	**Total Tourism Income**	**30% Coastal Tourist-Related Income/Day**
San Juan*	$37,400,000	$30,740
Skagit*	$47,900,000	$39,370
Whatcom*	$99,000,000	$81,370
Island*	$38,200,000	$31,397
Jefferson*	$22,800,000	$18,740
King*	$1,866,000,000	$1,533,699
Kitsap*	$51,400,000	$42,247
Mason*	$24,100,000	$19,808
Pierce*	$177,000,000	$145,479
Snohomish*	$158,400,000	$130,192
Thurston*	$52,600,000	$43,233
Clallam*	$39,200,000	$32,219
Victoria	$168,000,000	$138,082
Vancouver	$550,000,000	$452,055
TOTAL	**$3,332,000,000**	**$2,738,630**

Table 60: Impact on Tourism by Oil Spill Scenarios						
Response	**% Area Covered by Oil (> 1 g/m^2)**					
	5th	**50th**	**95th**	**Mean**	**Mean+2SD**	**Mean-2SD**
No Response	6.41%	2.97%	2.50%	3.96%	8.23%	0.00%
Mechanical-Federal	1.10%	0.00%	0.87%	0.65%	1.81%	0.00%
Mechanical-State	0.47%	0.00%	0.80%	0.42%	1.23%	0.00%
Mechanical-3rd	0.44%	0.03%	0.85%	0.44%	1.26%	0.00%
Dispersant-Federal	0.37%	0.00%	0.72%	0.36%	1.08%	0.00%
Dispersant-State	0.49%	0.02%	0.85%	0.45%	1.28%	0.00%
Dispersant-3rd	0.37%	0.00%	0.72%	0.36%	1.08%	0.00%

Table 61: Impact on Tourism by Oil Spill Scenarios						
Response	**Reduction in Tourist Spending and Income**					
	5th	**50th**	**95th**	**Mean**	**Mean+2SD**	**Mean-2SD**
No Response	$13,239,301	$6,134,278	$5,163,534	$8,179,038	$16,998,354	$0
Mechanical-Federal	$2,271,955	$0	$1,796,910	$1,342,519	$3,738,399	$0
Mechanical-State	$970,744	$0	$1,652,331	$867,474	$2,540,459	$0
Mechanical-3rd	$908,782	$61,962	$1,755,602	$908,782	$2,602,421	$0
Dispersant-Federal	$764,203	$0	$1,487,098	$743,549	$2,230,647	$0
Dispersant-State	$1,012,053	$41,308	$1,755,602	$929,436	$2,643,729	$0
Dispersant-3rd	$764,203	$0	$1,487,098	$743,549	$2,230,647	$0
Assumes 30-day reduction in tourism for diesel spills, 60-day reduction for crude spills, and 90-day reduction for Bunker spills, with 30% loss of tourist dollars.						

Value of Lost Oil

The market value of the spilled oil is an additional economic impact of an oil spill, assuming that the oil cannot be recovered and sufficiently processed for use for anything other than waste oil. The value of the lost oil for the scenarios is shown in Table 62. The value of the lost oil is not dependent on the location of the spill, its spread or impact, or the response methodology.

Table 62: Value of Oil Lost in Oil Spill Scenarios			
Oil Type	**Barrels Lost**	**Price Per Barrel[1]**	**Total Loss**
Crude Oil (Alaska North Slope)	65,000	$34.61/bbl	$2,249,650
Diesel Fuel	65,000	$42.00/bbl	$2,730,000
Bunker C	25,000	$32.59/bbl	$814,750
[1]Based on spot market prices in *Oil and Gas Journal* 12 July 2004			

Conclusions

Oil spills in Washington State could involve significant impacts to commercial fishing, Tribal Nations, subsistence fishing, ports, tourism, wildlife viewing and hunting, and other resources important to the state and to neighboring British Columbia and Oregon. The measure of these values as shown in this report is always difficult and often involves a variety of assumptions. These analyzed impacts do not include other important impacts that oil spills might have, such as that impact longer-term quality of life, psychological impacts, and spiritual values, that have been described anecdotally for other oil spills, particularly the Exxon Valdez oil spill (Fall, *et al*. 2001; Russell, *et al*. 2001). Overall, greater ability to remove oil offshore provides for less impacts of oil on the region's socioeconomic resources.

NATURAL RESOURCES POTENTIALLY PROTECTED BY TUG ESCORTS AND OTHER SPILL PREVENTION MEASURES IN SAN JUAN ISLANDS/ROSARIO STRAITS REGION, PUGET SOUND, WASHINGTON

A crude oil spill in the San Juan Islands/Rosario Strait area could also have a significant impact on wildlife and natural habitats in the area. The large number of islands and extensive shoreline that includes wetland areas, mudflats, and other sensitive habitats, as well as the rich diversity of birds, mammals, and other wildlife, increase the risk of impacts from oil spills in this area.

Environmental impacts can be measured in two ways – measure of actual wildlife mortality and injuries (with associated reduction in fecundity) or measure of the cost of rehabilitating impacted habitats to increase the likelihood of re-population of oil-damaged areas with wildlife species that were impacted. Natural resource damages (NRD) estimations are generally based on estimated costs to restore equivalent resources and/or ecological services. This is the preferred method used by natural resource trustees, based on guidance in the Oil Pollution Act of 1990 (OPA 90) regulations. Habitat Equivalency Analysis (HEA) was used to estimate the required amount of habitat (saltmarsh) restoration for NRD compensation of injuries to wildlife, fish and invertebrate species. Production by the restored habitat ultimately benefits wildlife, fish and invertebrates, and equivalency is assumed if equal production of similar species (*i.e.*, the same general taxonomic group and trophic level) results. It is considerably more difficult – and potentially contentious – to put a dollar value on individuals or populations injured or killed from an oil spill. In the analysis conducted for the SIMAP modeling and in the current analysis, the values for habitat equivalency analysis are used to estimate the environmental “costs” of a potential oil spill.

The State of Washington has a Damage Compensation Formula that it uses, generally for smaller spills, to assess natural resource damages for the purpose of seeking compensation from the responsible party for an oil spill. It does not, however, necessarily reflect the degree of damage from a spill, particularly those of larger volumes.

The majority of the biological impacts from oil spills in this area would be to birds, particularly to seabirds and waterfowl (diving ducks). Table 62 summarizes the bird impacts from spills of 65,000 barrels of crude oil in this area based on the same modeling criteria as under Socioeconomic Impacts (French-McCay, *et al.* 2004*a,b*).

Table 62. 65,000-bbl Crude Spill in San Juan Islands/Rosario Strait: Birds oiled.

Scenario	5th percentile	50th percentile	95th percentile	Mean	Standard Deviation (SD)	Mean - 2SD	Mean + 2SD
No Response	55,532	23,097	19,243	32,624	19,932	-	72,489
Mechanical-Federal	4,578	3,445	7,548	5,190	2,119	953	9,428
Mechanical-State	2,752	2,971	6,437	4,904	2,911	-	10,726
Mechanical-3rd	1,942	2,907	5,242	3,364	1,697	-	6,757
Dispersant-Federal	4,125	3,244	8,358	5,242	2,734	-	10,710
Dispersant-State	2,255	3,332	6,253	3,947	2,069	-	8,084
Dispersant-3rd	1,845	2,991	5,301	3,379	1,760	-	6,900

Table 63 shows that the mammal impacts are projected to be minor.

Table 63. 65,000-bbl Crude Spill in San Juan Islands/Rosario Strait: Mammals oiled.

Scenario	5th percentile	50th percentile	95th percentile	Mean	Standard Deviation (SD)	Mean - 2SD	Mean + 2SD
No Response	4	2	1	2	1	-	5
Mechanical-Federal	0	0	1	0	0	0	1
Mechanical-State	0	0	0	0	0	0	0
Mechanical-3rd	0	0	0	0	0	0	0
Dispersant-Federal	0	0	1	0	0	0	1
Dispersant-State	0	0	0	0	0	0	1
Dispersant-3rd	0	0	0	0	0	0	0

Table 64 summarizes impacts to subtidal fish and invertebrates (those in the water exposed to water and submerged sediment concentrations). The impacts for crude oil are not as high as they would be for a more toxic refined product such as diesel. This is because Alaskan crude oil emulsifies rapidly, minimizing entrainment and dissolution into the water.

Table 64. 65,000-bbl Crude Spill in San Juan Islands/Rosario Strait: Total impact (kg) to subtidal fish and invertebrates.

Scenario	5th percentile	50th percentile	95th percentile	Mean	Standard Deviation (SD)	Mean - 2SD	Mean + 2SD
No Response	2,543	14,919	1,363	6,275	7,509	-	21,293
Mechanical-Federal	1,705	16,231	4,527	7,488	9,570	-	26,627
Mechanical-State	1,337	15,651	2,768	7,886	6,807	-	21,499
Mechanical-3rd	1,462	14,537	2,152	6,050	7,724	-	21,499
Dispersant-Federal	12,057	14,380	4,369	10,269	8,063	-	26,395
Dispersant-State	4,683	16,535	4,319	8,512	7,791	-	24,094
Dispersant-3rd	1,689	17,291	2,104	7,028	9,208	5	25,445

In the scenarios examined, use of dispersants on crude oil spilled in the straits increases the impacts on fish and invertebrates, while impacts to birds and shorelines are not significantly reduced because the mechanical removal is assumed to be a relatively large effort and very efficient. If the mechanical response could not be accomplished at the assumed efficiency/capacity and dispersants were used, there likely would be some reduction in the bird and shoreline impacts to counter the increase in fish and invertebrate impacts. However, in confined waters, there may not be a net benefit of dispersant use. The San Juan Islands/Rosario Strait and the inner straits/Puget Sound scenarios would be ones where the net effects of dispersant use would likely be negative even if the mechanical response capacities were not fully utilized.

Impacts to intertidal invertebrates (Table 65) are evaluated for geoducks, soft-shell clams, razor clams, and hard clams in soft shoreline habitats (wetlands, mud flats and sand beaches). The main species affected in the straits scenarios is the geoduck, an important fishery species. The impacts to clams are proportional to the shoreline area heavily oiled. Thus, removal of oil from the surface, which results in less shoreline oiled, reduces the impact to intertidal clams.

The impacts to wetlands, mudflats, rocky shores, gravel shores, and sandy beach areas are shown in Tables 66 – 70.

Table 65. 65,000-bbl Crude Spill in San Juan Islands/Rosario Strait: Total impact (kg) to intertidal invertebrates (clams).

Scenario	5th percentile	50th percentile	95th percentile	Mean	Standard Deviation (SD)	Mean - 2SD	Mean + 2SD
No Response	19,976	8,273	12,992	13,747	5,888	1,972	25,523
Mechanical-Federal	472	1,132	3,397	1,667	1,534	-	4,736
Mechanical-State	252	566	1,636	1,134	716	-	2,566
Mechanical-3rd	315	786	1,132	744	411	-	1,566
Dispersant-Federal	503	944	3,209	1,552	1,452	-	4,455
Dispersant-State	252	786	1,636	891	698	-	2,287
Dispersant-3rd	346	786	1,070	734	365	5	1,463

The cost to restore the injured habitats and wildlife from the hypothetical modeled spill scenarios based on restoration of wetland areas are shown in Table 66.

Table 71. Impacts of 65,000-bbl Crude Spill in San Juan Islands/Rosario Strait: Total NRDA restoration costs (in millions of 2004$), assuming compensatory restoration is wetland creation.

Scenario	5th percentile	50th percentile	95th percentile	Mean	Standard Deviation (SD)	Mean - 2SD	Mean + 2SD
No Response	$43.70	$29.60	$15.40	$29.60	$21.70	$0.52	$72.90
Mechanical-Federal	$4.00	$14.10	$6.20	$8.10	$7.90	$1.17	$23.90
Mechanical-State	$2.50	$13.50	$5.30	$8.60	$6.90	$0.02	$22.50
Mechanical-3rd	$2.00	$12.60	$4.30	$6.30	$7.10	$0.33	$20.50
Dispersant-Federal	$11.70	$12.60	$6.80	$10.40	$7.30	$0.64	$24.90
Dispersant-State	$4.80	$14.50	$6.40	$8.60	$7.20	$0.30	$22.90
Dispersant-3rd	$2.10	$14.80	$4.30	$7.10	$8.30	$0.26	$23.70

Conclusions

Environmental impacts from crude oil spills in the San Juan Islands/Rosario Strait include bird mortality and impacts to fish and invertebrate populations. Natural resource damages, as calculated by compensatory restoration costs for wetland creation, amount to nearly $30 million for a spill of 65,000 barrels of crude oil. These impacts can be reduced by more effective oil recovery or dispersion on the water to reduce the spread of the oil and its impact on shorelines and nearshore habitats.

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